The American Midland Naturalist

Founded by J. A. Nieuwland, C.S.C.

Editor
John D. Mizelle, Zoology

ASSOCIATE EDITORS

Edward Albert Chapin, Washington, D. C. ..... Entomology
Albert L. Delisle, Notre Dame, Ind. ..... Plant Morphology
Carroll Lane Fenton, New Brunswick, N. J. ... Invertebrate Paleontology
John Hobart Hoskins, Cincinnati, Ohio ..... Paleobotany
George Neville Jones, Urbana, Ill. ..... Plant Taxonomy
Remington Kellogg, Washington, D. C. ..... Mammalogy
Jean Myron Linsdale, Monterey, Calif. ..... Ornithology
George Willard Martin, Iowa City, Iowa ..... Mycology
Hugh M. Raup, Petersham, Mass. ..... Plant Ecology
Karl Patterson Schmidt, Chicago, Ill. ..... Ichthyology and Herpetology
Harley Jones Van Cleave, Urbana, Ill. ..... Invertebrate Zoology

Vol. 41, 1949

(January - May)

PUBLISHED BY THE UNIVERSITY OF NOTRE DAME
NOTRE DAME, INDIANA

SCIENCE
LIBRARY
QH
1
A5

Science
Epch

CONTENTS

No. 1, January, 1949

The Birds and Mammals of the Vanderhoof Region, British Columbia ..... J. A. Munro 1
Mammal Remains in Owl Pellets ..... Ernest C. Driver 139
The North American Chrysopilus (Rhagionidae—Diptera) ..... D. Elmo Hardy 143
Notes on the Distribution of Michigan Mosquitoes (Diptera, Nematocera) ..... Carl B. Obrecht 168
Second Supplement to the Flora of Mount Shasta ..... Wm. Bridge Cook 174
Embryological Studies in the Orchidaceae. I. Gametophytes ..... B. G. L. Swamy 184
Embryological Studies in the Orchidaceae. II. Embryogeny ..... B. G. L. Swamy 202
The Resin Sac Pattern in the Needles of Engelmann Spruce and Blue Spruce from Southeastern Wyoming ..... John F. Reed and George F. Freytag 233
Taxonomy and Distribution of North American Cat-tails ..... Neil Hotchkiss and Herbert L. Dozier 237
Book Reviews 254

No. 2, March, 1949

Taxonomic and Biological Investigations in the Genus Megastigmus With Particular Reference to the Taxonomy of the Nearctic Species (Hymenoptera: Chalcidoidea; Callimomidae) ..... H. E. Milliron 257
Distribution of Leptorhynchoides thecatus, a Common Acanthocephalan Parasitic in Fishes ..... David R. Lincicome and Harley J. Van Cleave 421
An Additional Trematode from Tortugas, Florida, and a New Name for Opisthoporus Manter, 1947, Preoccupied ..... Harold W. Manter 432
A Survey of the Shore-Line Fauna of the Norfolk Peninsula ..... Frederick F. Ferguson and E. Ruffin Jones, Jr. 436
The Daily Activity Patterns of Some Freshwater Fishes ..... Kenneth D. Carlander and Robert E. Cleary 447
Annotated List of Original Descriptions in Scirpus ..... Alan A. Beetle 453
A New Dracontium from Southern Mexico ..... Eizi Matuda 494
Pugillus Astragalorum X: New Species, Varieties and Combinations ..... R. C. Barneby 496
Some Interesting Plant Records from Trans-Pecos, Texas ..... L. C. Hinckley 503
Additional Notes on Some Illinois Plants ..... G. D. Fuller and G. N. Jones 507
Book Reviews 512

No. 3, May, 1949

Study of Snake Populations in Central California ..... Henry S. Fitch 513
The Genera of Gerrhonotine Lizards ..... J. A. Tihen 580
The Loci of Contact Chemoreceptors in Insects—A Review With New Evidence ..... Hubert Frings and Mable Frings 602
An Experiment on Peromyscus Homing ..... Lucille F. Stickel 659
Studies on the Parasitic Helminths of the North Central States. II. Helminths of Voles (Microtus spp.) Preliminary Report ..... Robert Rausch and Jack D. Tiner 665

On the Occurrence of Algal Remains in the Ancient Rocks of Angola ..... P. Vasconcelos 695
The Teloschistaceae of Wisconsin—Papers on Wisconsin Lichens. III. ..... John W. Thomson, Jr. 706
Notes on Wisconsin Parasitic Fungi. XI. ..... H. C. Greene 714
Notes on Wisconsin Parasitic Fungi. XII. ..... H. C. Greene 726
Notes on Wisconsin Parasitic Fungi. XIII. ..... H. C. Greene 740
The Ovule and the Development of the Female Gametophyte in Homonia retusa Muell. and Euphorbia oreophila Miquel ..... D. M. Gopinath and K. S. Gopalkrishnan 759
Book Reviews 765

Dates of Publication
VOLUME 41, 1949

January ..... March 31
March ..... April 27
May ..... May 31

The American Midland Naturalist

Published Bi-Monthly by The University of Notre Dame, Notre Dame, Indiana

VOL. 41 JANUARY, 1949 No. 1

The Birds and Mammals of the Vanderhoof Region, British Columbia

J. A. Munro

Canada Department of Mines and Resources
Okanagan Landing, British Columbia

CONTENTS

Introduction 1
Acknowledgements 3
The Lakes District 4
Vertebrate habitats (terrestrial) 5
Aspen-spruce forest 5
Grasslands and shrub thickets 6
Open fields 7
Willow and alder swamp 7
Sinkut meadows 7
Lodgepole pine forest 10
Sinkut Mountain 11
Vertebrate habitats (aquatic) 12
Nulki Lake 12
Tachick Lake 16
Stony Creek 18
Sinkut Lake 20
Bradley's Slough 21
Manson's Slough 25
Forest meadows and forest ponds 28
Bird Migration 28
Post-nesting concentration of ducks 33
Loss of young ducks on nesting grounds 34
Subcutaneous infestation of passerine birds by *Protocallifora* 35
Berries as food for birds 38
Descriptions of other localities visited .. 39
The Nechaco River near Vanderhoof 39
Stuart Lake and Tachie River 39
Stuart River 41
Cluculz Lake 41
Annotated list of birds 42
The mammals 123
Annotated list of mammals 124
References 133
Index 134

INTRODUCTION

The present paper deals with a study of the bird and mammal fauna inhabiting the Vanderhoof Region, British Columbia, particularly that part lying some 12 miles south of Vanderhoof Village and known locally as the "Lakes District." Totals of 187 species and subspecies of birds and 28 species of mammals are recorded, the majority on the basis of specimens or personal observations. Field work was carried on from a base at Nulki Lake during the periods May 4 to September 4, 1945; June 8 to July 5, and August 6 to 29, 1946.

From this base the adjacent territory was studied in detail, and at intervals trips were made north to Nechaco River, Stuart River and Stuart Lake, west to Fraser Lake and the east end of Francois Lake and east to Cluculz Lake (Fig. 1). The investigation, however, was directed chiefly towards

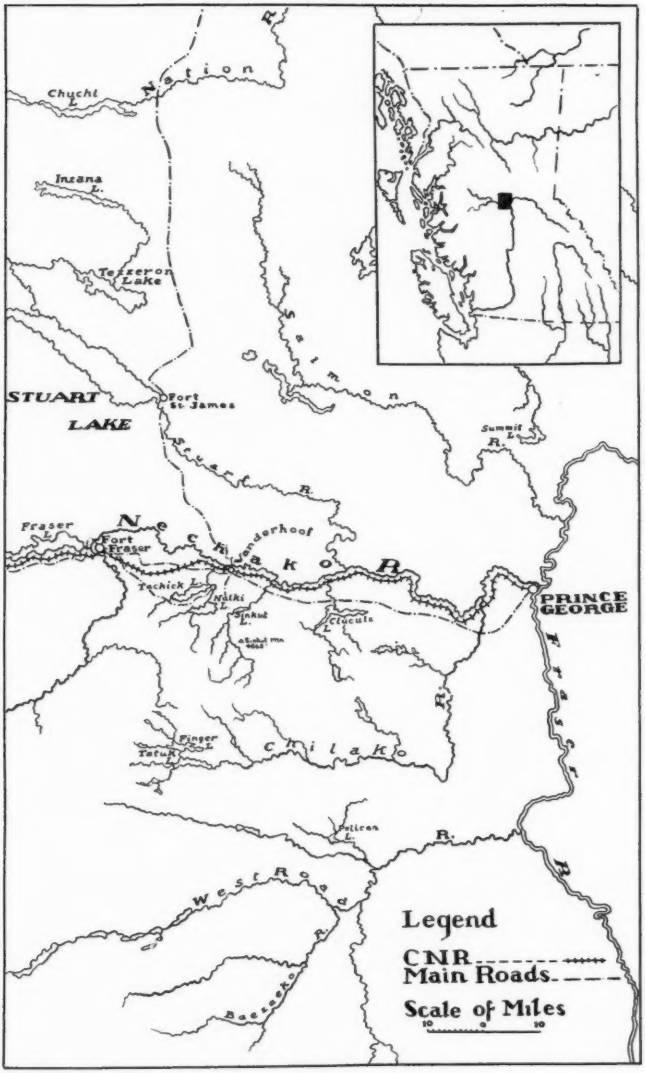


Fig. 1. The Vanderhoof region.

an intensive study of the Lakes District. It included the following activities, viz., study of the region's physiography; recording the spring migration of waterfowl and land birds; studies of waterfowl populations, their reproduction, food habits, natural enemies and post-breeding concentrations; studies of nesting land birds and their reduction in numbers by a destructive fly; collecting and preserving a representative collection of plants; the trapping of small mammals and studies of mammal populations.

The region, situated on an important migration route used by both waterfowl and land birds, proved to be one of exceptional interest. In summer it contains a relatively large waterfowl population and a widely diversified avifauna that includes elements generally associated with regions to the south, to the north and to the east.

It is believed that no zoological investigations had previously been made in the Lakes District. The late John Macoun passed through there in 1876, but in the report covering his journey no mention is made of the fauna (Macoun 1877). There is, however, information available concerning Stuart Lake, some 35 airline miles to the northwest, and concerning Vanderhoof. The first is due to the activities of the late Roderick MacFarlane, who was officer in charge of the Hudson Bay Post at Fort St. James, Stuart Lake, in the years 1887 to 1899 inclusive. During that time, but principally in May and June of 1889, he made a collection of birds' nests and eggs, many of the specimens being accompanied by one or both of the parent birds. Apparently all this material was sent to the United States National Museum, Washington, D. C. His paper *Birds of Northern Canada* (Mair and MacFarlane 1908) includes references to 30 species of birds of which skin specimens or sets of eggs were collected in the vicinity of Fort St. James. A reported nesting of the black-throated loon at Stuart Lake is probably an error in identification, and the references to black and white warbler evidently errors in typography. Otherwise the identification of specimens would seem to be acceptable.

Mr. Wm. Spreadborough spent the period Aubust 14 to 16, 1919, at Vanderhoof collecting birds for the Canadian National Museum. Precise information as to his activities is lacking, but it is known that he collected some 56 birds of 30 species.

ACKNOWLEDGMENTS

Game Warden Phil Brown, Vanderhoof, contributed valuable data relating to the spring migration of ducks and geese; he guided, or directed me, to localities of special interest. Mr. John Henry, a student at McGill University, accompanied the party for two months in 1945 and took on the trapping of small mammals during that time; Mr. Robert Howe, Indian Affairs Branch, arranged for my visit to Grand Rapids, Tachie River; Mr. and Mrs. Robert Collins, Mr. and Mrs. Wm. Evans, Mr. and Mrs. George Evans, Mr. and Mrs. Roy Bradley, Mr. and Mrs. Platt Bradley, Mr. and Mrs. Adam Dickson, and other members of the Lakes District settlement, including the pupils of the local school, supplied natural history items of interest; Mr. George Evans and Mr. Roy Bradley accompanied me in the field on several occasions. All the local residents were hospitable and friendly; they contributed not only to the amount of information assembled but also performed acts of kindness which will not soon be forgotten.

Many of the plants and invertebrates mentioned in this report were identified by the

following authorities, viz.: Mr. George Hardy, Mr. J. W. Eastman, plants; United States National Museum, molluscs; Mr. George Holland, fleas; Dr. H. B. Hungerford, water bugs; Mr. Hugh B. Leech, aquatic Coleoptera; Mr. George Spencer, Diptera; Dr. Herbert H. Ross, caddis flies; Dr. A. L. Rand supplied information relating to bird specimens from Vanderhoof in the Canadian National Museum collection. Mr. B. A. Sugden prepared the accompanying map.

Grateful acknowledgment is made to all persons mentioned for their valued cooperation and kindness.

THE LAKES DISTRICT

The Nechaco River, draining the great circle of lakes in Tweedsmuir Park, flows in a northeasterly direction some 50 odd miles, to a point within half a mile of Fraser Lake, then, making a sharp right-angle turn, continues 75 miles southeast to join the Fraser River at Prince George. Within this wide angle of the river, and forming part of its southern drainage, is an undulating and forested plain, at an altitude under 3000 feet, extending south some 10 miles where it rises to a series of low mountains. A portion of the territory north of the hills is accessible in dry weather by the old Telegraph Road from Fort Fraser to Quesnel, now in disrepair and seldom used. Another portion, south and west of the escarpment of the Nechaco River at Vanderhoof, is reached by means of a good secondary road (crossing Telegraph Road near Nulki Lake) that serves a small agricultural community centered about the east end of Nulki Lake, the east end of Tachick Lake and the west end of Sinkut Lake. The region, known as the Lakes District, includes the most valuable waterfowl nesting area so far discovered in British Columbia north of the Cariboo Parklands.

The portion of this section lying between the lakes and the Nechaco River, a distance of approximately six miles, is a series of elevations and depressions forested chiefly with lodgepole pine *Pinus contorta* and aspen *Populus tremuloides*. Some of the depressions contain small wild-hay meadows, flood-ponds and impermanent sedge marshes. Here are several occupied farms and some land that once cleared, then abandoned, has grown up with aspen.

Farther south, in the agricultural belt adjacent to the lakes, the forest is predominantly aspen with only an occasional lodgepole pine and numerous small stands of Engelmann spruce *Picea Engelmanni*. Here are cultivated fields bordered by this type of forest (Fig. 2). Within the forest are sedge meadows, varying in size from a fraction of an acre to five acres or more. All contain water, some only in spring, others, in years of normal precipitation, throughout the summer and autumn. Prominent also are the open grasslands and rounded hill-tops covered with low shrubbery. Two large sloughs, known as Manson's Slough and Bradley's Slough, are important feeding and nesting places for waterfowl.

South of the lakes, the aspen-spruce forest, the agricultural land, the meadows and grasslands — about nine airline miles south of the Nechaco River — a steep escarpment rises some 200 feet to a region of lodgepole pine forest. The Sinkut River draining to Sinkut Lake has cut a precipitous, narrow valley through these higher benches and not far above the last of the meadow land it passes through a steep-walled canyon.

Sinkut Mountain, altitude 4,782 feet, situated fourteen airline miles south of Vanderhoof, is the highest point close to the Lakes District. The north slopes of the mountain are mostly burned-over lodgepole pine with little green showing except where there is aspen replacement. Farther to the southwest are the somewhat higher Nulki Hills, 4,876 feet altitude, maximum.

VERTEBRATE HABITATS
(Terrestrial)

ASPEN-SPRUCE FOREST

Aspen predominates in this association. It includes few straight, pale-barked specimens; most of the trees, even the saplings, are ill-shaped and straggly with blackish-stained bark, as though affected by some type of blight. Many are short with spreading crowns, and a large proportion of older specimens have deeply corrugated bark. A large amount of windfall and many dead, standing trees attest that fires have been of frequent occurrence. There is much underbrush of which service berry *Amelanchier alnifolia* is first and black twin-berry *Lonicera involucrata* second in abundance. Engelmann spruce is scattered through the forest and occurs also, chiefly on the ridges, in clear stands that include specimens up to 16″ in diameter. Elsewhere small, compact stands of uniformly slim specimens 50 to 60 feet in height form dark, dense woods, where only in the few openings does the sunlight, in a checkerboard pattern, reach the dry needle-covered floor. In such openings a stunted black twin-berry, or a thin-trunked willow, reaches spindly branches upward to the light.

The snow had melted when, on May 4,* I first visited the aspen woods, and, except in moist depressions, the forest floor seemed exceedingly dry. Innumerable ants *Formica rufa melanotica* swarmed everywhere on the ground, on windfalls and on the living trees. Large ant-hills, some five feet in height, the largest 44 feet in circumference, were conspicuous objects amongst the aspens and in the spruce stands (Fig. 3). Later it was discovered that these ants were destructive to bird-life.

No sign of spring growth appeared in the woods during the early part of May but by May 16, after several days of rain, the topmost aspen branches, exposed to direct sunlight, were tinted with the yellow-green of new leafage. On this date too, green was first seen on the forest floor, as the young leaves of meadow rue *Thalictrum* sp., strawberry *Fragaria* sp., yarrow *Achillea* sp. and dandelion *Taraxacum officinale* appeared. A small blue violet had recently flowered, and black twin-berry was leafing out. By May 22 aspens were in half-leaf; Canada violet *Viola canadensis*, twisted stalk *Smilacina amplexifolius*, and golden corydalis *Corydalis aurea* had blossomed; Oregon grape *Berberis* sp. and meadow rue were in bud. On May 28 the aspens had leafed out completely and on June 1 arnica *Arnica* sp., black twin-berry, and service berry in the forest openings, were in full bloom. Other conspicuous plants that came into flower in the aspen woods as the season progressed are listed below:

* All dates given are for the year 1945 unless otherwise indicated.

Habenaria viridiflora Rydb. (Rein Archid)
Habenaria stricta Lindl. (Rein Orchid)
Habenaria orbiculata Torr. (Round-leaved Rein Orchid)
Corallorhiza multiflora var. *occidentalis* Lindl. (Coral Root)
Corallorhiza maculata Raf. (Large Coral Root)
Stellaria longipes Goldie. (Chickweed)
Rubus pubescens Raf. (Dewberry).
Fragaria glauca (Wats.) Rydb. (Strawberry)
Aquilegia formosa Fischer (Red Columbine)
Vicia americana Muhl. (American Vetch)
Viola adunca Smith (Dog Violet)
Galeopsis Tetrahit L. (Hemp-nettle)
Castilleja sp. (Indian Paint-brush)
Aster apricus Gray (Howell) (Aster)
Clematis columbiana Hornem. (Clematis)

In mid-June, when the aspens provided generous shade, and the leafage of an almost continuous underbrush hid the windfall, these woods looked exceedingly attractive. At times they were full of bird-song, nesting hermit thrush, warbling vireo, ruby-crowned kinglet, siskin and purple finch all contributing their quota. Other nesting birds were red-breasted sapsucker, Wright flycatcher, American robin, black-capped chickadee, red-breasted nuthatch, Audubon warbler and chipping sparrow.

GRASSLANDS AND SHRUB THICKETS

Here and there on the northern shores of Tachick Lake and Nulki Lake are open stretches of grasslands (Fig. 4) usually including open knolls covered with thickets of soopolallie *Shepherdia canadensis*, service berry, choke cherry *Prunus* sp., and wax berry *Symphoricarpos racemosa*. The largest examples of this type of habitat are situated on two peninsulas which enclose a fairly deep bay at the east end of Nulki Lake, referred to in this report as Middle Bay.

On some knolls soopolallie, on others service berry, is dominant; both are conspicuously abundant. Service berry appears in two types, a low shrub usually under two feet in height growing in the open, and a tall bush usually situated at the edge of the grasslands and in openings in the aspen woods (Fig. 5). Both had commenced to unfold leaves and flower buds on May 8 and were in full bloom on May 28; so also was choke cherry. Soopolallie was in blossom on May 3 and commenced to leaf out three weeks later.

Plants characteristic of these grasslands are:

Sisyrinchium sp. (Biue-eyed Grass)
Anemone multifida Poir. (Wind-Flower)
Corydalis aurea Willd. (Golden Corydalis)
Arabis glabra (L.) Bernh. (Tower Mustard)
Arabis Drummondi Gray (Rock Cress)
Arabis microphylla Nutt. var. *Macounii* (S. Wats) Rollins (Rock Cress)
Potentilla monspeliensis L. (Rough Cinquefoil)
Potentilla biennis Green (Cinquefoil)
Potentilla gracilis Dougl. (Slender Cinquefoil
Potentilla dissecta Pursh var. *glaucophylla* Wats (Cinquefoil)
Geum strictum Ait. (Yellow Avens)
Gilia gracilis Hook. (Gilia)
Collinsia parviflora Dougl. (Blue-eyed Mary)
Pentstemon procerus Dougl. (Beard-Tongue)
Aster conspicuous Lindle (Large Purple Aster)
Aster Lindleyana T. & G. (Lindley's Aster)
Aster Eatoni (Gray) Howell (Aster)
Solidago lepida DC var. *elongata* (Nutt.) Fernald (Slender Golden-Rod)
Solidago lepida DC var. *fallax* Fernald (Golden-Rod)

Helianthus subrhomboideus Rydb. (Sunflower)
Achillea sp. (Yarrow)
Arnica mollis Hook. (Arnica)
Arnica amplexicaulis Nutt. (Arnica)
Senecio pauciflorus Pursh. (Ragwort)
Antennaria parviflora Nutt. (Mountain Everlasting)
Crepis tectorum L. adv. from Eu. (Hawk's Beard)
Scabiosa arvensis adv. from Eu (Scabious)

This type of habitat is not very attractive to birds; the commoner species present during the summer were vesper sparrow, savannah sparrow and chipping sparrow.

OPEN FIELDS

Fields sown to oats and wheat, others in summer fallow, all margined by the aspen and spruce forest constitute a distinct bird-habitat (Figs. 1, 6). Fields in summer fallow produced a dense crop of weeds, and various kinds of birds foraged there throughout the season. In early spring horned larks and pipits fed there daily; marsh hawks quartered the fields systematically, hunting the abundant meadow voles. Later on came crows, red-wing blackbirds and Brewer blackbirds attracted by a scattered supply of waste oats; the fields were feeding grounds also for killdeer, vesper sparrow and savannah sparrow.

WILLOW AND ALDER SWAMP

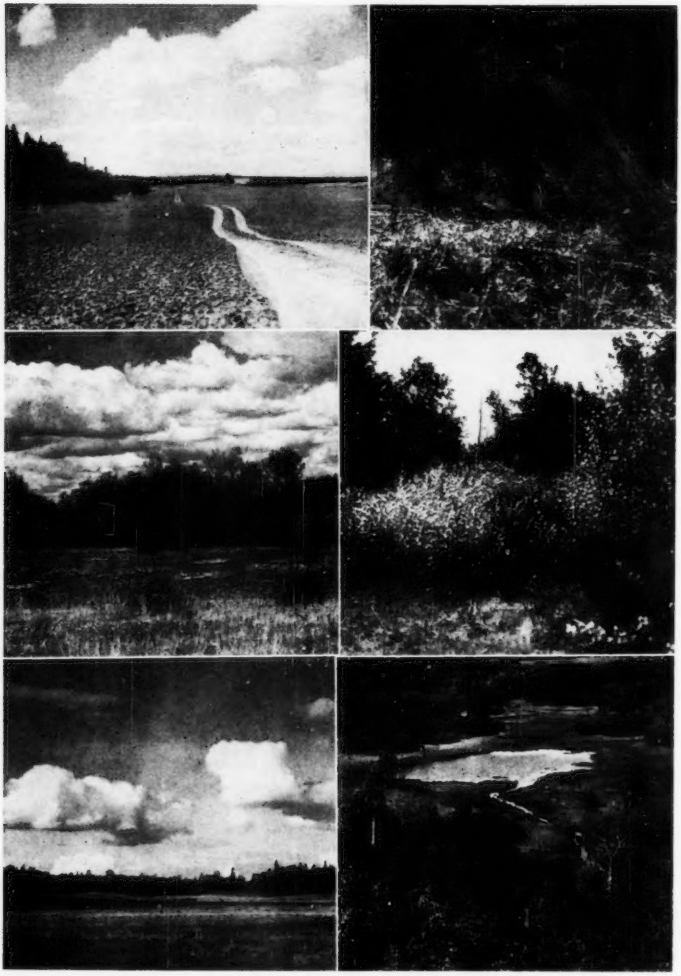
There is a large amount of this type of habitat, much of it along the shores of the lakes. One such place about five acres in extent, situated near our base, was kept under fairly regular review. It forms a conspicuous point on the peninsula at the northwest corner of Middle Bay. The constituent elements of this particular swamp are: dense thickets of brushy willow and alder; open, flooded areas of sedge and horsetail; dry, open places covered with a tall plumed grass interspersed with dogwood thickets and black twin-berry; dry, alder thickets; the lake margin, treed with tall alder, willow and a few small, black cottonwood and including a small patch of cattail. At the back the land slopes to grasslands, shrubbery and stands of tall aspen.

When first inspected on May 10 no sign of new growth was visible either in the shrubbery or in the sedges; by June 1 willows and alder were in full leaf, sedges and horsetail 12 to 18 inches above the water. The last year's growth of plumed grass had fallen to form masses two feet in thickness, and here and there through them a few new shoots had forced their way. No green showed in the cattails.

Rufous hummingbird, alder flycatcher, yellow warbler, yellowthroat, redstart, water thrush, Lincoln sparrow and song sparrow were conspicuous in this swamp, and in others of the same type. Downy woodpecker and Swainson thrush were less frequently seen there; mallards and blue-winged teal nested in them.

SINKUT MEADOWS

Between the east end of Nulki Lake and the west end of Sinkut Lake, a distance of approximately three miles, is a stretch of flat bottomland averaging one mile in width. Possibly at an earlier time the flat was under water,



Figs. 2-7: 2. Fields in the Lakes District bordered by aspen and lodgepole pine; 3. Colony of the ant *Formica rufa melanotica* at Nulki Lake; 4. Typical grasslands, Nulki Lake; 5. Service berry in blossom, Nulki Lake; 6. Field in summer fallow, Nulki Lake; 7. A marshy slough that drains into Sinkut Lake. (Read figs. from left to right beginning at top.)

forming a wide, shallow channel between the two lakes; at any rate there remains what appears to be evidence of an earlier submergence in the form of sand and gravel areas. For the most part, however, the bottom is overlaid with a deep deposit of rich alluvial soil. Some is cultivated and grows good crops of timothy and clover but the greater portion is covered by a heavy growth of willow and alder interspersed with open sedge meadow and low shrubbery. Near Sinkut Lake a marshy slough about one acre in extent drains directly into Sinkut Lake through a narrow, sluggish stream (Fig. 7).

The Sinkut River (known locally, and referred to in this paper, as Sinkut Creek) rising in the Nulki Hills to the south winds through the southeastern portion of the bottom and enters Sinkut Lake through a thick wood of tree-sized willow and alder. It flows over a hard, sandy bed, and, at low water, across a hard sand and mud beach that extends 50 yards or so into the lake. In August this beach is a feeding place for waders, and a resting place for ducks and gulls. Above the willow and alder wood the river becomes a fine stream flowing over a gravel bed in a series of riffles and deep pools. When I first saw it, on May 30, the spring flood had subsided but the stream was 20 feet wide in places, and the brown water, darkened still more by silt, was running strong. At flood time it inundates the sedge meadows near the lake and, higher up, its changing channel eats into the grasslands so that the stream bed between low, eroded banks is yearly growing wider. In places along the stream, above the willow woods at the mouth, are tall cottonwoods, alder and willow; higher, where the valley narrows between steep hills, are groves of western birch *Betula occidentalis* and western dogwood *Cornus pubescens*.

In late May meadows were yellow with dandelion bloom — later, wide expanses were silvered with the multiude of seed-heads. Native plants that flowered earliest were: coltsfoot *Petasites sagittatus*, valerian *Polemonium humili*, bunchberry *Cornus canadensis*, and crowfoot *Ranunculus repens*. Later the following plants were listed from these meadows:

Smilacina amplexicaulis Nutt. (False Solomon's Seal)
Smilacina stellata (L) Desf. (Star-flowered Solomon's Seal)
Disporum trachycarpum B. & H. (Fairy Bells)
Habenaria viridiflora Rydb. (Rein Orchid)
Actaea arguta Nutt. (Baneberry)
Delphinium scopulorum (Larkspur)
Arabis lyrata L. var. *occidentalis* Wats. (Rock Cress)
Erysimum cheiranthoides L. (Wormseed Mustard)
Mitella caulescens Nutt. (Mitrewort)
Geranium richardsonii F. & M. (White Geranium)
Heracleum lanatum Mich. (Cow Parsnip)
Aralia nudicaulis L. (Wild Sarsaparilla)
Trientalis latifolia Hook. (Star Flower)
Gentiana acuta Michx. (Northern Gentian)
Mertensia paniculata Don. (Lungwort)
Galium boreale L. (Northern Bedstraw)
Erigeron lonchophyllus Hook. (Fleabane)
Artemisia canadensis Michx. (Sagebrush)
Arnica mollis Hook (Arnica)

Prominent in the shrubbery are: willows, alder, highbush cranberry *Viburnum pauciflorum*, swamp gooseberry *Ribes lacustre*, black currant *Ribes* sp., and black twin-berry. One bush of hardhack *Spiraea Douglasii* was observed near Sinkut Lake; apparently this species is uncommon.

The vegetation is similar in some respects to that in the bottomlands near Quesnel but is less varied and less luxuriant. The tall undergrowth of fern

characteristic of that region is lacking; only the oak fern *Phegopteris Dryopteris* was found here.

In late July, on open places amongst the aspens on the north slope, Indian paint-brush bloomed in great profusion, making carmine splashes against a massed white background of northern bedstraw. On lower ground cow parsnip and delphinium grew rank amongst the shrubbery — the total forming jungle-cover for sparrows and warblers. Later, places in the bottom glowed pink with the blossoming heads of firewood.

This brushy and wooded meadow held a denser nesting population of birds than any other habitat; later it was thronged with transients. Characteristic summer birds were: rufous hummingbird, downy woodpecker, alder flycatcher, ruby-crowned kinglet, bank swallow, rough-winged swallow, Brewer blackbird, yellow-throat, water thrush, American redstart, clay-colored sparrow, white-throated sparrow, Lincoln sparrow and song sparrow.

LODGEPOLE PINE FOREST

A level bench above the escarpment of Sinkut Creek, and an area extending south to the wide burns on the slopes of Sinkut Mountain, are covered by lodgepole pine forest; in general it is open and park-like; sandy soil predominates and the trees average about 10 inches in diameter. Here and there amongst the pines are occasional stands of Engelmann spruce, some of large size, and where the land falls steeply to the narrow valley of upper Sinkut Creek, are a few old Douglas fir *Pseudotsuga Douglasii* Raf. There is little underbrush, the only species observed being juniper *Juniperus communis*, alder, birch-leaf spiraea *Spiraea lucida*, rose *Rosa Sayi*, and highbush cranberry. The numerous aspen scattered through the forest clumps are made up of straight, clean-barked specimens, quite different from those in the valley below. In some places kinnikinnick *Arctostaphylos uva-ursi* grows in a thick carpet; in others club moss, grasses and forbs dominate much of the forest floor. In flower during late June and July, were tiger lily *Lillium parviflorum*, clematis *Clematis columbiana*, bunchberry, Indian paint-brush, northern bedstraw, twin-flower *Linnaea borealis*, goldenrod, yarrow and arnica. Additional plants recorded from this habitat are:

Silene latifolia Brit. & Ren. (Bladder Campion)
Saxifraga tricuspidata Rottb. (Saxifrage)
Pyrola chlorantha Swartz (Wintergreen)
Pyrola asarifolia Michx. (Wintergreen)
Melampyrum lineare Lem. (Cow wheat)
Artemisia canadensis Michx. (Sagebrush)
Senecio cymbalarioides Nutt. (Ragwort)
Senecio pseudaureus Rydb. (Ragwort)

Bird life was less abundant than in the better habitats at lower elevations. Characteristic of the lodgepole pine habitat are: yellow-shafted flicker, red-breasted sapsucker, western wood pewee, Canada jay, mountain chickadee, red-breasted nuthatch, hermit thrush, Townsend solitaire, solitary vireo, Audubon warbler, western tanager, red crossbill, Oregon junco, and chipping sparrow.

A small lake, about two acres in extent, one of several on the flank of Sinkut Mountain, is surrounded by a narrow strip of sedge marsh; *Potamoge-*

ton gramineus is abundant along the shallow margin. The only large patches of blueberry *Vaccinium* sp. in the district grow close to this lake. Water birds observed on July 2 were: a buffle-head with brood, one pair of killdeer and two adult spotted sandpipers. Several pairs of song sparrows nested in the shrubbery along the margin of the enclosing forest. In late summer, when the lake level had dropped, a few waders visited the muddy shores. Thus on August 23, three greater yellow-legs one lesser yellow-legs, two killdeer, two solitary sandpiper and one least sandpiper were seen there. The surrounding belt of sedges and grasses is a feeding ground for moose; tracks often were found there and once a good view of a cow moose was obtained. Here a dusky shrew and a *Synaptomys* were trapped, this being the only place where the first was taken.

SINKUT MOUNTAIN

Sinkut Mountain, although rising only to 4,782 feet altitude, is a dominant feature in the topography of the Lakes District (Fig. 8). The north and west slopes, originally covered with lodgepole pine, Engelmann spruce, and a lesser amount of alpine fir *Abies lasiocarpa* Hook (Nutt.), have been burned over several times, the last fire being in 1932. Old burns on the lower levels are reproducing lodgepole pines; on the higher levels, and extending close to the rocky summit, are dense thickets of alder, willows, and aspen. The summit, about five acres in extent, is a jumble of granitic rocks; the few trees, lodgepole pine and Engelmann spruce, are stunted — but true alpine conditions do not prevail at this altitude. Neither hoary marmot nor pika inhabit either of the two large rock slides that lie just below the summit. Depressions filled with soil are covered with clumps of phlox *Phlox Douglasii*, kinnikinnick, juniper and various saxifrages. There is a small amount of moss heather *Cassiope* sp. In low places are grass and sedge patches; a shrubbery of alder, dwarf birch *Betula glandulosa*, rhododendron *Rhododendron albiflorum* and a dwarfed soopolallie occupies one depression. Other plants are:

Equisetum sylvaticum L. (Horsetail)
Veratrum viride Ait. (False Helebore)
Habenaria dilatata Hook. (Rein Orchid)
Rumex acetosa L. (Sorrel)
Cerastium campestre Greene (Mouse-ear Chickweed)
Stellaria laeta Rich. (Chickweed)
Sedum stenopetalum Pursh. (Stonecrop)
Potentilla nivea L. (Cinquefoil)
Solidago decumbens Greene (Golden Rod)
Achillea borealis Bong. (Yarrow)
Artemisia borealis Pall. (Sage)
Artemisia canadensis Michx. (Sage)
Senecio triangularis Hook (Ragwort)

Looking east from the summit one sees part of Cluculz Lake; to the southwest lie two lower summits, separated by forested valleys, the Nulki Hills are beyond (Fig. 9); to the north the twin lakes, Nulki and Tachick, and the smaller Sinkut Lake, are conspicuous on the wide plain stretching beyond them to the mountains at Stuart Lake. It is said that peaks in the Rocky Mountains and in the Coast Mountain ranges are plainly visible on a clear day, a condition which did not prevail when I was there.

The only birds seen on the summit, on August 19, were two pine siskins and one sharp-shinned hawk; the only mammals seen were chipmunks.

VERTEBRATE HABITATS

(Aquatic)

NULKI LAKE

This is a shallow lake, 5 miles by 1¼ to 2 miles, reported not to exceed a depth of 30 feet in the deepest portion, while extensive shoreward areas average less than three feet. The water is clear except late in summer when it becomes turbid with blue-green algae. Two prominent peninsulas, featured by eroded or steeply sloping banks falling away from grasslands, shrub-thickets and aspen wood, project from the east shore. These two peninsulas (the highest and longest of many that give the lake its irregular shoreline) together with the portions of the north and south shores opposite to them, form the sides of three, deeply-indented bays, referred to in the following account as North Bay, Middle Bay (Fig. 10) and South Bay. North Bay continues relatively deep close in to shore; it is used as a booming ground by a small logging and milling enterprise; Middle Bay and South Bay are shallow, two to three feet in depth 100 yards from shore. Both have a rich and varied aquatic flora that includes *Potamogeton pectinatus* and other pondweeds, arrow-head *Sagittaria latifolia,* water buttercup *Ranunculus* sp., water midfoil *Myriophyllum* sp. and hornwort *Ceratophyllum* sp. Large patches of water smartweed *Polygonum amphibium* grow there; in the shore marshes *Riccia carpus, Lemna minor, L. trisulca* and *Spirodella polyrhiza* are abundant. Middle Bay has a sandy beach that attracts numerous waders on their southern migration.

The littoral of the entire lake is of three general types, viz.: hard sand, or gravel beach, succeeded inshore by aspen, black cottonwood and an occasional western birch; hard shores overhung with tall alders and willows; low-lying swampy land, covered with willows that form a background to marshes of sedges, cattails, round-stem bulrush, horsetail and bur-reed.

On the south shore, near the entrance to South Bay, a tributary stream known as First Creek enters the lake through an alder thicket. At the mouth the stream is about 10 feet wide, and shallow over a gravel bar. It was possible, in May, to paddle a canoe 50 yards or so upstream; beyond, overhanging alders, and numerous dead trees embedded in the channel, prevented further progress.

A short distance to the west is a quarter-mile stretch of marsh. On its landward side the growth is chiefly sedge in which *Carex rostrata* is dominant; outside the sedge is a wider belt of horsetail; on its outer margin are small beds of round-stem bulrush. The bottom is hard overlaid with six to twelve inches of mud and desiccated vegetation. Proceeding west along the south shore it is seen that the marsh ends abruptly; farther on, for one-half mile or so, the shores are hard; alder, willow and a few black cottonwood margin a continuous spruce and aspen forest. Beyond is the point of a peninsula where a low alder-covered bank (an old ice-formed ridge) screens an inland sedge marsh. Here are black cottonwoods and behind them a stand of tall Engelmann spruce. Several hundred yards west of the tip of the peninsula, Second Creek, flowing through a wide flat covered with tall black cottonwoods, enters

the lake over a gravel beach. In the territory between the mouth of Second Creek and the mouth of Corkscrew Creek, a distance of approximately three miles, are numerous small marshes composed of the plants referred to above. In some places each species grows separately and one type of marsh succeeds another; a portion of a marsh several hundred yards long, and over its entire width, may be composed of one species only. In other places two species, usually horsetail and bur-reed, or horsetail and round-stem bulrush, grow in parallel belts along the shore. On the margin of many are wide areas of yellow pond lily.

Corkscrew Creek, the main tributary, enters the lake through a wide meadow, the course of the stream outlined by willows. The channel, at the mouth and for some distance upstream, has a hard sand bottom. Here the stream has practically no current; on one side is a small sedge marsh, on the other small alder and willows (Fig. 11). From near the outlet of Corkscrew Creek, around the west end of the lake, and east along the north shore for slightly less than a mile, is a continuous belt of marsh. This is first-class nesting and feeding ground for waterfowl. The shallows contain a dense vegetation of yellow pond lily, water buttercup, water milfoil, hornwort and pondweeds including *Pontamogeton natans, P. Freisii, P. zosteriforma, P. pectinatus* and *P. richardsonii.* The tributary Stony Creek, that enters the lake at the west end, has an insignificant flow and dries up completely in summer.

The north shore is similar to the south shore with numerous small marshes, some composed exclusively of bur-weed *Sparganium androcladum.* About two miles from the east end of the lake is a narrow, shallow bay, the bottom covered with *Potamogeton pectinatus* and other pondweeds, the shores outlined by horsetail, cattail and round-stem bulrush. From this bay Stony Creek flows in a northeasterly direction and drains Nulki Lake into Tachick Lake.

About half-way along the north shore, west of Stony Creek, is a narrow, wooded peninsula with a beach of hard, red sand, and behind it is an open meadow at lake level — referred to in this paper as Collins' Marsh. At one place the meadow is separated from the lake by only a narrow gravel ridge grown up with aspen, black cottonwood and willow. In years of high water the meadow is flooded from the lake; at times it has been dry and one year at least a portion was cultivated. For several years up to 1945 much of it was under water and a fine marsh became established there. In June, 1945, it consisted of some 20 acres of sedge and cattail, standing in water up to 20 inches in depth. On two sides the marsh area is bordered by grasslands, and on the other two by alder and willows that flank the aspen woods. The cattails were in small islands surrounded by open pools and tall sedges. None of the pools was more than five or six hundred square yards in extent. The outer margins of the marsh, in shallow water, was composed of various sedges, rushes and grasses, and, growing amongst them, water smartweed, mints, water buttercups and numerous other hydrophytic plants. Redhead, American coot, sora, Wilson phalarope and red-wing blackbird were found nesting there in 1945.

The marsh was completely dry in 1946 and it contained no waterfowl.

Figs. 8-13: 8. Sinkut Mountain, a dominant feature in the landscape of the Lakes District; 9. The Nulki Hills seen from the summit of Sinkut Mountain; 10. Middle Bay, Nulki Lake; the last of the ice along the shore; 11. The mouth of Corkscrew Creek; 12. Marshes of cattail, horsetail and bur-reed, Tachick Lake 13. Water hemlock amongst round-stem bulrush at Tachick Lake. (Read figs from left to right beginning at top.)

There is one island in Nulki Lake, situated opposite the entrance to Middle Bay and about one mile offshore. It is narrow, about one-half mile long, and covered with young aspen — following a fire that a few years ago burned off the original aspen and spruce forest. Now only a few of the older trees are standing, and the ground is covered by a tangle of fire-blackened trunks.

The country surrounding Nulki Lake, as has been indicated, is a rolling plain on which a forest of aspen and Engelmann spruce is broken by open grasslands. Spruce is much more plentiful, and the terrain is rougher, along the south shore of the lake than it is on the north shore, a condition characteristic of many lakes in Central British Columbia. The cultivated lands adjacent to the lake are chiefly about the east end. There are only three occupied places on the north side of the lake and only one on the south.

The waterfowl-food resources of Nulki Lake are very large, so is the total of nesting habitat. The lake is shallow enough so that no part of it is unproductive — diving ducks feed over its whole length and breadth. Reference has been made to the abundance of plant food. Animal food includes: amphipods *Gammarus limnaeus, Hyalella azteca*; leeches; water bugs *Sigara bifida, Callicorixa audeni*; the molluscs *Anodonta oregonensis* Lea, *Sphaerium sulcatum* (Lamarck), *Stagnicola preblei* (Dall), *Helisoma subcrenatum* (Carpenter), *Physella ampullacea* (Gould), *Planorbula campestris* (Dawson), *Stagnicola palustris nuttalliana* (Lea), *Musculium ryckholti* (Normand), *Pisidium liljeborgii* Clessin; the following aquatic coleoptera: *Agabus ontarionis* Fall, *Agabus erichsonii* G. & H. *Hydaticus modestus* Sharp., *Colymbetes? longulus* Leconte, *Dytiscus circumcinctus* Ahrens, *Hygrotus impressopunctatus* Schaller, *Hydroporus* sp., *Helophorus* sp., *Gyrinus confinis* LeConte, *Hydrobius fuscipes* L.; chironomid larvae; odonata nymphs and numerous other nymphs and larvae of aquatic insects.

The concentrations of waterfowl observed during the spring migration, and during summer, are described in other sections of this paper. It will be appropriate here perhaps to record a census made during a circuit of the lake by boat on July 24.

Holboell grebe	16	adults, 12 young
Mallard	6	adult males
Baldpate	300	adults, chiefly post-breeding males, 24 females, 141 young
Blue-winged Teal		female with brood of 6
Green-winged Teal		female with brood of 5
Shoveller		female with brood of 5
Redhead		female with brood of 7; female, brood not seen
Lesser Scaup Duck	700,	including yearling males and females, post-breeding males and 4 females plus 38 young
Barrow Golden-eye	200	yearlings, band of 40 young of several ages, 3 young unattended, 5 females plus 31 young
Buffle-head	8	females plus 44 young
White-winged Scoter	5	
Surf Scoter	5	
Ruddy Duck	1	
American Coot	4	adults, 4 young
Black Tern	150	adults, 40 flying young

TACHICK LAKE

This lake, 7½ miles by ¼ to 1½ miles, is situated approximately 2½ miles north of and parallel with, Nulki Lake. The two lakes are connected by Stony Creek, the name given also to the stream that drains Tachick Lake into the Nechaco River.

The physiography of the two lakes is similar; Tachick Lake is the deeper of the two with a reported maximum depth of 50 to 60 feet near the west end. The water, as in Nulki Lake, becomes fouled with blue-green algae in late summer, but in the heavy weed beds at the west end the water remains clear. Most of the north shore is rocky below a 15 to 30 foot bank; the forest cover is chiefly aspen with an occasional Engelmann spruce, the littoral tree-growth predominantly willow with lesser amounts of black cottonwood. alder and dogwood. Along the shore are numerous round-stem bulrush marshes, many with yellow pond lily beds in front of them. Except for one 300-yard stretch of reed grass *Phragmites communis*, these marshes are continual from the east end of the lake for a distance of about two and one-half miles; where there is no marsh growth, willows and alder overhang the rocky shore. Westward, for another three miles or so the last type of cover predominates and the marshes are shorter and narrower — there are no beaches. Beyond, round-stem bulrush again becomes plentiful; near the west end of the lake it is replaced to some extent by areas of cattail, horse-tail and bur-reed — each species forming a separate marsh (Fig. 12).

The east half of the south shore is rocky. The adjoining forest cover is chiefly aspen, except for one stand of scrubby Engelmann spruce reaching to the water's edge for about one mile, one marsh-fringed meadow, and a long peninsula where black cottonwoods are prominent behind a round-stem bulrush marsh which is nearly one-half mile long. Round-stem bulrush marshes predominate and are continual, except on the portion fronting the spruce forest where there is little emergent growth. The west portion of the south shore is low and boggy covered by the characteristic willow, alder, aspen, spruce association. As on the north side, so on the south side of this portion of the lake, round-stem bulrush is partly replaced by marshes of cattail and bur-reed. As elsewhere these are in separate beds, those some distance from the shore being divided by navigable channels. Here and there amongst the bulrushes are clumps of water hemlock *Cicuta Douglasii* (Fig. 13). Near its western extremity the lake narrows to form a bay of some 800 acres. Its western shore is a continuous cattail and sedge marsh. Round-stem bulrush is established in islands; the two largest, 200 yards by 50 yards approximately, are several hundred yards out from the shore. In this bay the water is less than four feet deep in most places; the bottom, both in the open lake and in the marshes is a soft, marl-like, but extremely productive, mud. Yellow pond lily, with floating leaves, covers areas up to an acre and more in extent and the entire lake bottom carries a heavy growth of pondweeds and other submerged aquatics.

Tachick Creek enters the west end of the lake through a marsh-fringed willow bottom. The stream, for several hundred yards above the mouth, has no perceptible current; the depth on July 8, 1945, was about five feet; the

bottom was covered with pondweed and other aquatics. It might be correct to describe this channel as a narrow inlet of the lake rather than as the stream proper, which has only a slight flow, and, higher up, dries out in summer. According to Provincial map, Pre-emptor series, No. 3B, it originates in Welch Lake about 10 miles to the southeast, but I met no one who could corroborate this. Tachick Creek and Stony Creek are the only tributaries of Tachick Lake.

Near its east end the lake narrows to less than one-half mile and the tributary Stony Creek enters, over a hard gravel bottom, at the eastern extremity. For several hundred yards out the water is shallow; the bottom is hard and supports a luxuriant flora. On either side of the creek-mouth the shores are boggy with a plentiful growth of round-stem bulrush and cattail. The inshore marsh, of shorter growth, is composed chiefly of sedges and grasses.

The outlet of the lake (Stony Creek) is on the north side, diagonally across the bay and about 1½ miles distant from the creek-mouth referred to above. The entrance to the creek is approximately 100 feet wide, the depth about 5 feet; there is no perceptible current (Fig. 14). *Potamogeton Friesii* and *P. richardsoni* grow abundantly there. A short distance beyond, the stream widens; one of the boggy shores is fringed by alder and willows; the other by marshes of cattail and round-stem bulrush. The stream is slow-moving for one-half mile or so; below it narrows to a rocky channel that is general for the remainder of its eight-mile course to the Nechaco River. This part of Stony Creek, on which are several falls, was not inspected.

Food resources in the lake are of a high order. Flora on the hard bottom near the east end is dominated by the pondweed *Potamogeton richardsonii*; this is the common species over much of the main lake, but in July its abundance was obscured by turbidity of the water due to blue-green algae efflorescence. In the shallow bay at the west end are dense forests of *Potamogeton zosteriformis, P. Friesii,* and relatively lesser amounts of widgeon grass *Ruppia occidentalis,* water buttercup and hornwort. Vegetation of one kind or another covers the lake bottom in all this shallow portion and by July 4 it had made a dense surface foliation; on August 8 the water was still clear and cool. Through gaps in the matted foliage it could be seen that numerous gastropods littered the marl bottom while here and there were bryozoan colonies, the largest 1½ inches in diameter. The duckweeds, *Lemna minor* and *Lemna trisulca,* are plentiful in many of the marshes; round-stem bulrush and numerous species of sedges and grasses produce an abundance of seeds; amphipods (*Gammarus limnaeus, Hyalella azteca*) are present in great numbers, so also are various species of snails including *Stagnicola palustris nuttalliana* (Lea), *Helisoma subcrenatum* (Carpenter), *Sphaerium rhomboideum* (Say)?, odonata nymphs, and larvae of many other kinds of insects.

Tachick Lake has outstanding value as a nesting ground, as a resting and feeding place, and as a place of concentration for post-breeding and non-breeding yearling ducks.

When first visited, on May 7, portions of the lake shore at the west end and on the south shore were inspected on foot. At that time ice still covered some of the lake surface and no green appeared in the marshes. It was not

practicable to estimate the total population because many birds were congregated on patches of open water, and many others on the ice, far out from shore. An estimate of the population on about one-tenth of the lake's surface is as follows: Holboell grebe—200±; baldpate—10; greater scaup duck and lesser scaup duck—600±; canvas-back—2; buffle-head—50±; surf scoter—50±; red-breasted merganser—2; American coot—100±.

On July 4 a complete circuit of the lake, following the shore line into each of the bays, was made by boat. Shore marshes, and the submerged vegetation in the lake, were probably at the height of their summer's growth. The following count, carefully made, indicates the diversity of the waterfowl community, but it by no means is to be considered a census of the nesting population, for it seems probable that only a fraction of the number of pond ducks with broods was observed. Most of the baldpate, redhead and lesser scaup ducks were associated on a small area in the shallow bay at the west end.

Loon	1
Holboell Grebe	24 adults, 8 young
Western Grebe	1
Pied-billed Grebe	1
Mallard	4 males, 2 females, 1 female with 12 young
Pintail	1 female
Baldpate	80±, chiefly adult males; 3 females with broods
Redhead	40±, chiefly males; 1 brood of 5 downy young
Ring-necked Duck	10 males
Lesser Scaup Duck	100±, chiefly yearlings, plus 15 pairs
Golden-eye, probably *islandica*	15 yearlings, 8 adult females plus 78 young
Buffle-head	25 yearlings, 9 adult females plus 49 young
White-winged Scoter	14
Ruddy Duck	1
American Coot	30±
Black Tern	70±

During later inspections by canoe, chiefly at the west end of the lake, additional duck and coot broods were recorded; all five species of grebe were observed or heard; the nesting of eared grebe, yellow-headed blackbird and long-billed marsh wren was established. None of the other marshes, inspected in Central British Columbia, contained this variety of bird-life.

STONY CREEK

Stony Creek, between Nulki Lake and Tachick Lake, winds through an open, narrow valley for approximately 2½ miles. The upper half of the stream is shallow; large boulders show above the surface, and there are numerous riffles. Stony Creek Indian village is situated on an open flat, through which the stream flows, about a mile north of Nulki Lake. Below the village the stream widens and deepens. In early July there was little current, the water was clear and cold; the stream from below the village of Tachick Lake varied from 20 feet to 75 feet in width and most of it could be navigated by canoe. The shores are boggy with cattail, horsetail, sedge, and bur-reed marshes alternating, except where willows, alder and dogwood overhang the water. Along the margins are beds of buckbean *Menyanthes*

trifoliata, water arum *Calla palustris*, marsh cinquefoil *Potentilla palustris*, and two types of yellow pond lily, one with erect leaves and one with floating leaves. A mile or so above the outlet the stream divides into two or more channels as it passes through an ancient beaver meadow several hundred yards in width. Parts of this marsh are dominated by tall bur-reed. The only patch of reed grass found on the stream is established alongside a pool near the Indian village. The conspicuous plants cover an area of some 500 square feet.

Food plants are abundant in the stream and in the marshes. The duckweeds *Lemna minor* and *Spirodela polyrhiza* cover the surfaces of quiet, shaded areas and occur in enormous quantities in the marshes. Buckbean, pond lily, arrowhead and sedges are also important in the food potential. The bottom vegetation in the stream is dominated by the valuable hornwort that in great mats completely fills parts of the channel; the pondweed *Potamogeton richardsonii*, widgeon grass and a water buttercup with a white blossom, are less plentiful.

Amphipods, *Gammarus limnaeus* and *Hyalella azteca*, are present in great numbers amongst the mats of hornwort; molluscs *Valvata lewisii helicoidea Dall, Promenetus exacuous* (Say), *Gyraulus hirsutus* (Gould), *Physella ampullacea* (Gould), *Pisidium idahoense* Roper, *Pisidium variabile* Prime?, are plentiful; a caddis larva *Limnophilus* sp. was found in masses, several square yards in extent, on portions of the sandy stream bed. The fish life, as observed, consisted of coarse-scaled sucker, fine-scaled sucker, ling and lake shiner. It is reported that Kamloops trout spawn in the stream.

Stony Creek is an excellent nesting ground and feeding place for waterfowl. Owing to the difficulties in connection with exploring the marshes — too deep to wade and too dense to permit the use of a canoe — it was not possible to locate nests or broods there. However, the presence of a fairly large population was indicated by other evidence. A census taken July 3 on approximately one and one-half miles of stream travelled by canoe follows:

Horned Grebe	1
Holboell Grebe	1
American Bittern	2
Mallard	3 females, 4 males in eclipse
Blue-winged Teal	1 male
Baldpate	1 female
Shoveller	1 female with brood hidden in rushes
Redhead	1 female flushed twice, probably from a nest; 1 female with brood of 6; 7 non-breeding (?) females
Lesser Scaup Duck	1 pair, 4 males
Barrow Golden-eye	1 female with brood of 11; 1 female with brood of 8; 1 female with one young; 15 yearlings
Buffle-head	1 female with brood of 5; 4 yearling females
Ruddy Duck	1 male, 1 female
American Coot	1 female with brood of 6; 1 female with brood of 4; 1 female with brood of 2

SINKUT LAKE

Sinkut Lake, an expansion of Sinkut Creek, 2¾ miles by ½ to ¾ miles, is situated about three miles east of Nulki Lake. It is deeper than the last with a fairly straight shorelone of low, aspen-covered hills. The forest has been burned over numerous times and the less plentiful spruce reproduction is hidden by the young aspens. A few tall Douglas firs stand on some of the more open hill summits (Fig. 15). Engelmann spruce predominates on two small wooded islands about midway down the lake. There is no agricultural land except on the Sinkut Meadows, and beside the outlet of the lake at its eastern extremity from whence Sinkut Creek drains into the Nechaco River. The entire west shore, on either side of the beach at the outlet of Sinkut Creek, is flat, muddy territory covered with a marsh up to 100 yards wide composed of horsetail and sedge that are mingled in some places and separate in others; on the outer margin are yellow pond lilies. Inland is the characteristic belt of tall willows. Other smaller marshes of similar character are situated on the north shore and near the east end of the lake; none contains much suitable nesting cover for waterfowl.

The shallows at the west end are a feeding ground for waterfowl in early spring, some 1500 scaup, golden-eyes and other ducks were observed there, May 2, on a narrow strip of open water in an otherwise frozen lake. Holboell grebe and black terns, both apparently nesting, were seen each time the lake was visited; occasionally a baldpate or green-winged teal flushed from the marsh.

In all three lakes the following species of fishes are established, viz.: Kamloops trout *Salmo gairdneri kamloops*, Rocky Mountain whitefish *Prosopium williamsoni*, fine-scaled sucker *Catostomus catostomus*, coarse-scaled sucker *Catostomus macrocheilus*, squaw fish *Ptychocheilus oregonensis*, Columbia River chub *Mylocheilus caurinus*, lake shiner *Richardsonius balteatus*, ling *Lota maculosa*.

The trout population in Nulki Lake is exceedingly abundant, the average specimens caught by anglers measuring about 14 inches. Corkscrew Creek is the chief spawning ground. On this stream is a series of three small falls, the highest about six feet, and above them about ten miles of good spawning ground. When I visited this place on the evening of May 20 the stream was high, the water brown and the spawning-run probably at its height. Trout up to two and three pounds were leaping the largest of the falls, with what seemed the greatest ease; sometimes as many as six fish could be seen in the air at one time; many others were crowded into a deep, foaming pool below the falls.

The spawning run of fine-scaled suckers on Corkscrew Creek, on Sinkut Creek and elsewhere precedes that of trout; the spawning run of coarse-scaled suckers follows it. One observation made in connection with the last is that trout follow the run and feed upon suckers' eggs. The gullets and stomachs of a dozen or so trout caught by anglers on Sinkut Creek between June 10 and June 21 were filled with suckers' eggs. This was reported to me by reliable persons and I had the opportunity to verify the statement in connection with four trout caught on June 21. The stomach of one fish about

12 inches in length contained a mass of sucker eggs measuring approximately five cubic centimeters, those of the other three smaller fish held smaller amounts.

By June 20 Sinkut Creek was at summer level and the water was clear. In several shallow riffles over pebble-strewn beds numerous coarse-scaled suckers breasted the current, remaining motionless, except for the movements of their fins, for several minutes at a time. Undoubtedly these fish were spawning. One observer told me that under similar conditions he had watched trout lying close by the suckers and swallowing the eggs as they were laid. Several persons told me that trout taken in June below the falls on Corkscrew Creek commonly were filled to capacity with suckers' eggs.

The observation is of particular interest because it is customary in British Columbia to encourage the destruction of suckers, by means of intensive trapping, in the belief that suckers feed on trout eggs, and by so doing reduce the angling potential. I have been unable to find evidence that such is the case.

BRADLEY'S SLOUGH

This is a shallow, open slough with muddy bottom, approximately ½ mile long by ⅜ mile wide, occupying a depression in the Sinkut Meadows (Fig. 16). The following describes conditions as observed in 1945. The amber-colored water was clear, the maximum depth, in May, about five feet. The bottom was completely covered with vegetation — dominated by *Potamogeton pusillus*, amongst which were relatively small amounts of *Potamogeton pectinatus*, *P. richardsonii*, *P. amplifolius*, *Ceratophyllum demersum*, water smartweed and *Myriophyllum* sp. Arrowhead is plentiful in the shallowest portions close to the marshy shores. Animal food is varied but not abundant. Perhaps the spring concentration of diving ducks had reduced the supply by an appreciable amount. Amphipods, water bugs *Cymatia americana* and *Callicorixa audeni*, the molluscs *Stagnicola palustris nuttalliana* (Lea), *Aplexa hypnorum* (L.), *Planorbula campestris* (Dawson), the aquatic coleoptera *Hydrobius fuscipes* L., a *Gyrinus* sp., and the nymphs and larvae of various kinds of insects, were dredged from the bottom.

The slough is surrounded by a sedge marsh 10 to 30 yards wide on the north and south shores; on the west the marsh approximates five acres, and on the east it broadens to a wide meadow of 75 acres or more. The land rises slightly along the length of the depression and is heavily wooded with aspen and spruce, some of the last named 12 to 16 inches in diameter. Between the forest and the marsh is the usual belt of shrubbery, chiefly willow, alder and dogwood. On the north side for about 200 yards these species are replaced by tall dwarf birch.

The most plentiful sedge is a wide-leafed species, *Carex rostrata*. Fringing this dominant growth, at many places along the lake margin of the marsh, are patches of spike-rush *Eleocharis palustris*, manna grass *Glyceria grandis* S. Wats., a few clumps of cattail, and an occasional, isolated clump of sedge with narrow foliage of a gray-green color that renders it conspicuous amongst the prevailing rich green of other vegetation. Other grasses and sedges collected here are: *Alopecurus aequalis* Sobol., *Calamagrostis canadensis* var.

scabra (Presl) Hitchc., *Elymus hirsutus* Presl, *Fluminea festucacea* (Willd.) Hitch., *Phalaris arundinacea* L., *Carex aquatilis* Wahl, *C. atherodes* Spreng., *C. exsiccata* Bailey, C. *Stenochaena* (Holm.) Mack., *C. substricta* (Kukenth.) Mack. All provide good nesting cover, and the old, dry leaves of the sedges are the sole or main constituent in the nests of ducks, coot and red-wing blackbird.

In the meadow a fine-leafed sedge covers a wide area of land that dries out in early summer. This lies between two belts of coarse sedge, one along the lake margin, the other on wet ground at the meadow's periphery where sedges give way to willows. The fine sedge is cut for hay; the coarser sedges are not cut and the old growth provides nesting cover for ducks. Next to the lake the sedge meadow is dotted with a few small willows and dwarf birch that provide extra nesting-cover; so also do the willow bluffs that margin the meadow on three sides. Along two sides, close to where the land begins to rise, are a series of shallow pools that in June were yellow with the bloom of water buttercup, and water arum grew there. Other plants collected in wet ground beside the slough and in the meadow are listed below:

Arenaria lateriflora L. (Sandwort)
Ranunculus Purshii Richards (Buttercup)
Ranunculus sceleratus L. (Buttercup)
Ranunculus macounii Brit. (Buttercup)
Radicula palustris (L.) Moench. (Marsh Cress)
Cardamine occidentalis (S. Wats.) (Bitter Cress)
Parnassia montanensis Rydb. & Fer. (Grass of Parnassus)
Parnassia parviflora D. C. (Small-flowered Grass of Parnassus)
Potentilla palustris (L.) Scop. (Marsh Cinquefoil)
Geum rivale L. (Purple Avens)
Veronica americana Schwein. (Brooklime)
Galium bifolium Wats. (Bedstraw)
Valeriana sitchensis Bong. (Valerian)
Bidens sp. (Bur Marigold)

On parts of the dryer portions of the meadow are dense willow thickets with sedges underfoot, and other thickets of black twin-berry. Amongst this low growth are bluffs of tree-size willow, and groups of black spruce *Picea mariana* are prominent features. This territory contained a numerous land bird population, both in respect to number of species and number of individuals, equal and similar to other parts of the Sinkut Meadows. The following species, all probably nesting, were recorded there on June 27: rufous hummingbird, alder flycatcher, Tennessee warbler, MacGillivray warbler, yellow-throat, redstart, warbling vireo, savannah sparrow, white-crowned sparrow, Lincoln sparrow, swamp sparrow and song sparrow.

On May 5 the old growth of sedges at the margin of the slough were broken down with no green showing; the sedge meadow was in the same condition. By June 1 the new sedges stood 12 inches high, and new leaves two feet in length appeared in the few small patches of cattail at the marsh edge. The old, dry cover both in the lake marsh and meadow was by this time partly screened with new vegetation. On June 7 sedges and spike rush were in flower. No pondweeds or other of the bottom vegetation had reached the surface of the lake. The marsh in places was choked with water moss *Fontinalis* sp. in which duckweeds, *Lemna trisulca* and *Lemna minor*,

were present in large amounts. Buckbean, occurring only in small amounts, was in blossom.

By early July the marsh growth had reached its most vigorous period; tall sedges and still taller manna grass came into bloom; arrowhead blossoms whitened large areas along the shores; the water, perhaps chilled by underground springs, continued cool, maintaining a lower temperature than did the water of Nulki Lake. The slough level lowered rapidly in the hot days that followed; on July 17 the deepest portions measured only three feet and in the shallower portions vegetation, that earlier was submerged, lay on the surface. Areas of mud became exposed between the marsh edge and the water and to these places came lesser yellow-legs and other waders. At this time, too, the ponds along the alder-fringed sides of the depression dried out as did the formerly wet portions of the meadow.

Pond ducks and diving ducks of numerous species, and in relatively large numbers, frequented the slough during the spring migration. After the transients left, the residue of waterfowl was counted numerous times — the slough is small enough so that counts can be made with fair accuracy. Several counts in early June indicated the population to be about as follows: Holboell grebe, 1 pair; American bittern, 1 pair; mallard, 1 pair; pintail, 1 pair; green-winged teal, 1 pair; blue-winged teal, 8 pair; baldpate, 3 pair; redhead, 1 pair; ring-necked duck, 6 pair; lesser scaup duck, 2 pair; American golden-eye, 1 pair; Barrow golden-eye, 1 pair; buffle-head, 6 pair; American coot, 3 pair; sora, 6 pair.

It was considered that the open slough with its margin of marsh supplemented by the adjacent sedge meadows constituted a well-balanced nesting and rearing habitat for waterfowl. This proved to be right only in part because many of the ducks, which had established territories there during the courtship period, did not bring broods to the water. Other ducks, which did bring broods there, remained for only a short time. Presumably the majority finally took their broods to the larger Nulki Lake where animal food is more abundant.

Frequent and lengthy observations were made at this place. The following is a record of two hours in the life of the slough as observed on June 8, between 8:00 a.m. and 10:00 a.m.*

During this period the air was still following a hard shower, the water unruffled, reflecting shore growth and white clouds broken by patches of blue sky. The lake bottom, and the vegetation on it that had not yet reached the surface, became clearly visible. Ducks drifted on the quiet water, none except buffle-head and a group of yearling Barrow golden-eye exhibiting much activity. At one time or another all the duck population came under close review. Eight male blue-winged teal idled on a stretch of communal territory where the species had been observed frequently during the preceding three weeks (the day before, in the afternoon, all or most of them were accompanied by their mates). A male green-winged teal and two male baldpate drifted, or paddled slowly, along the margin of the sedges. Farther out,

* Pacific Standard Time here, and throughout this paper.

close together, were two pairs of ring-necked ducks and a third male; in the center of the lake a male redhead, bowing intermittently, swam a few feet behind his female. Three male ruddy ducks swam the full length of the lake but none dived for food nor performed any part of the courtship ritual. Three pairs of coots were on their territories, the males occasionally flattening on the surface with necks outstretched but no active display took place. There were few sounds other than the excited calls of nesting red-wing blackbirds. Several times a coot, and once a sora, cackled. Three male buffle-heads were in constant motion. One pursued another in flight and, after both alighted, the pursuer rushed across the water in a spirited challenge of the second male. Several times the three rose and pursued two females which appeared to be yearlings. Twice one of the males alighted beside a female golden-eye, rushed towards her and put her to flight. At 8:50 a.m. a female mallard, perhaps coming from a nest in the willows on the sedge meadow, slanted down to the water. A few minutes later two drake mallards alighted on the lake. At 9:05 a female Barrow golden-eye, undoubtedly coming from her nest, circled the lake twice, then dropped sharply and glissaded across the surface.

Evening, when most nesting females had joined the males, was the time of greatest activity. Diving ducks seemed to feed more at that time than during the day, ruddy ducks and golden-eyes close in shore, ring-necked ducks and lesser scaup farther out.

Day by day the pattern of life on the slough changed. The first young ducks, downy young of Barrow golden-eye, appeared on June 21. On June 23 six broods were counted, viz.: one American golden-eye, one Barrow golden-eye and four buffle-head. Later other ducks with their broods came to the water, remaining for a day or so, then disappeared; the coots led their few young elsewhere; sora became conspicuous along the marsh margin; waders of various species appeared on the mud flats. Then came a period, July 25 to August 10, when only a few broods of ducks were on the slough and finally all but a small band of buffle-head had disappeared. In mid-August post-nesting pond ducks commenced to gather there, feeding in the weed-filled shallows and loafing on the open water. They puddled in the beds of arrowhead until the water thickened with mud. The concentration of pond ducks which took place there in the last two weeks of August was the largest observed in the district.

TABLE 1.—Estimates of ducks on Bradley's Slough, August, 1946.

August	8	16	17	19	20	21	22	24	26	28
Mallard	–	600	500	400	3	400	400	25	3	100
Pintail	24	125	35	40	150	100	200	400	760	1100
Green-winged Teal	–	10	–	–	–	1	–	–	25	30
Baldpate	–	75	40	20	300	200	200	150	550	800
Barrow Golden-eye	6	–	–	8	4	2	–	–	–	–
Buffle-head	–	20	28	30	20	20	–	–	1	1

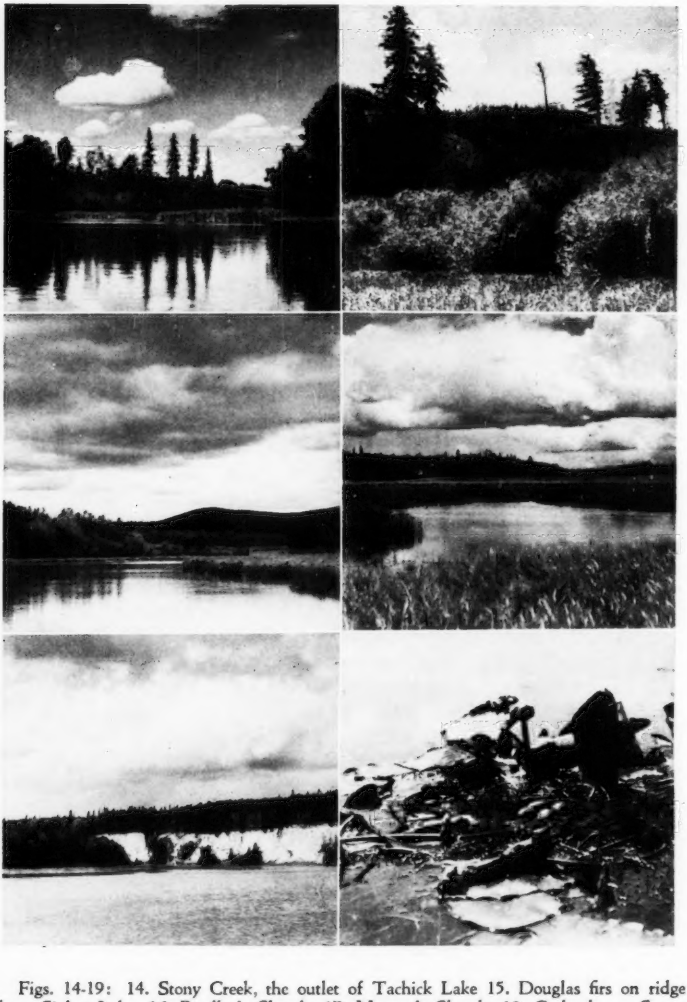
In June, 1946, the water level was lower than it had been in September, 1945. The water area continued to shrink in size until by August it was surrounded by a wide border of exposed lake-bottom composed of peculiarly elastic mud. The marshes dried out entirely and large masses of arrow-head and a tall *Ranunculus* became stranded. This happened in spite of the fact that abundant rains, and cool weather, persisted through June and July; vegetation in the meadows and grasslands grew tall and heavy and the country was still richly green in early August. In late August massed yellow bloom of bur marigold stood above the marsh sedges to form a conspicuous circle of color around the slough. No grebe, ruddy ducks, coot nor sora nested there, and the number of ducks using the slough as a nursery was reduced. However, in late summer pond ducks congregated as they had done through approximately the same period in 1945 (See table 1). Waders visited the muddy margin in relatively large numbers.

MANSON'S SLOUGH

This is a 30 to 40 acre sedge marsh, containing numerous ponds and channels of open water in Section 6, Township 2, Range 4 Coast Land District. It is surrounded by open fields sloping from the margin of the marsh to the edge of the aspen woods on higher ground. Some of the fields are cultivated.

On May 4, 1945, no green was visible in the vegetation, neither in the sedges of the marsh proper where clumps of old growth stood six inches above the water, nor on adjacent muddy ground where the same type of sedge is dominant. Farther inshore last year's accumulation of manna grass and slough grass *Bechmannia syzigachne* lay in windrows. Inshore still farther a higher and drier belt of vegetation — the final one on the margin of cultivated land — was without sign of life. By May 22 the new growth of sedge, now 10 to 12 inches high, was sufficient to screen the water in marsh and narrow channels — the larger pools were still conspicuous (Fig. 17). On May 27 the taller sedges, growing in water, averaged 18 inches; those inshore on muddy ground averaged only half that height. No green had yet appeared amongst the accumulation of dead grass that featured the intermediate belt of vegetation. On the outermost belt dandelions were in flower, obscuring the slower-maturing native plants. On June 16 sedges in the marsh were in flower, manna grass had attained a height of 15 inches, and the vegetation on higher ground had reached a stage where it provided adequate cover for the blue-winged teal and other pond ducks that nested there. The last cover to mature was the manna grass that did not flower until the first week of July; it had then reached an average height of five feet.

The chief food plant in the ponds is sago pondweed *Potamogeton pectinatus*; this covers about ninety per cent of the bottom. The only other plant at all abundant is the less valuable water milfoil; duckweed *Lemna minor* occurs in small quantities among the sedges. The seeds of the sedges, the less plentiful spike rushes, and the abundant dock *Rumex maritimus* undoubtedly are important in the economy of the slough. Small animal life, except for corixids, is not abundant and neither amphipods nor molluscs were found there.



Figs. 14-19: 14. Stony Creek, the outlet of Tachick Lake 15. Douglas firs on ridge above Sinkut Lake; 16. Bradley's Slough; 17. Manson's Slough; 18. Cutbanks on Stuart River; 19. Nest of eared grebe on pond lilies, Tachick Lake. (Read figs. from left to right beginning at top.)

There seemed reason to believe that some of the nesting population obtained part of their food on Nulki Lake, and on Bradley's Slough, both less than a mile distant. Ducks frequently were seen in flight from Manson's Slough to Nulki Lake, or *vice versa*; ducks not belonging to Bradley's Slough, and thought to have come from Manson's Slough, sometimes were observed feeding there.

Manson's Slough attracted many transient waterfowl including swans and geese and a relatively large and varied bird population nested there. During the latter part of the spring migration, in early May before new vegetation had obstructed the view, the marsh and its surroundings was a scene of great activity. Whistling swans fed amongst the flooded sedges — burying long necks and tipping up posteriors — or gliding about on open stretches of water; for a week or more a flock of Canada geese grazed along the outermost margin; pectoral sandpipers and greater yellow-legs frequented the muddy shore. Shovellers, the males conspicuous amongst the dark sedge tussocks and scarcely less so as they took off in excited courtship-flight, were the most plentiful pond duck. Redhead, ring-necked duck, lesser scaup duck and buffle-head were observed swimming about in plain view whenever the place was visited. No shooting is permitted on or near this slough and large numbers of ducks are said to visit it in autumn.

By the time the last transients left the marsh cover had grown sufficiently to obscure much of the flooded area and it proved impossible to accurately count the residual, and presumably nesting, population. Observations were made still more difficult in June by the almost constant wind that swept over the marsh, lashing the tall sedges and deadening all bird voices save those which came from close at hand. Nevertheless it was clear that the nesting population was large, a fact borne out later by the evidence of nests found.

Baldpate, green-winged teal, blue-winged teal, shoveller and savannah sparrow nested along the outside circle of short vegetation; redhead, coot, sora, black terns, yellow-throats and red-wing blackbirds nested amongst the sedges. To this marsh, later on, came post-breeding male baldpate and other pond ducks.

The nesting population was thought to consist of the following, viz.: mallard, 2 pair; green-winged teal, 4 pair; blue-winged teal, 16 pair; baldpate, 6 pair; shoveller, 5 pair; redhead, 4 pair; buffle-head, 1 pair; ruddy duck, 2 pair; sora, 4 pair; coot, 7 pair; black tern, 35 pair; red-wing blackbird, 6 pair.

The water-level commenced to drop about mid-June and by June 27 it became possible to wade through much of the marsh. Some of the matted sago pondweed lay completely exposed on the wet mud. Here and there through the marsh were found duck sitting-places covered with droppings and duck feathers, chiefly those of blue-winged teal.

By July 28 the small ponds had dried, the deeper ones held a foot-deep mass of muddy water and massed sago pondweed; it was possible to wade the entire length of the slough. Many shed duck feathers were found; a total of 16 pond ducks was flushed; red-wing blackbirds with flying young still frequented the marsh. In the days following the remaining water evaporated; on August 22 the slough was observed to be completely dry.

It continued dry through 1946; terrestrial weeds and grasses were established where sago pondweed, water buttercup and other aquatics had flourished the year before.

FOREST MEADOWS AND FOREST PONDS

At many places in the forest are open sedge meadows, up to 20 acres and more in extent, fringed with willow and other shrubbery. One of 18 acres, another of 12 acres approximately, were visited frequently. The two meadows were about 200 yards apart, and separated by a low, forested ridge. The larger one, in early May before any new sedge growth appeared, was flooded to a depth of six inches; it was a feeding ground for pectoral sandpiper, solitary sandpiper and greater yellow-legs; rusty blackbirds frequently were seen there. It was dry by June 14 and in late August an expanse of sun-dried skunk grass *Hordeum jubatum* covered the entire area and hid the sedges. The smaller meadow included a pond, measuring about 100 feet by 50 feet on May 16, that was visited by mallard, blue-winged teal and buffle-head. It contained a rich invertebrate fauna including dragonfly nymphs, midge larvae, the molluscs *Planorbula campestris* (Dawson), *Musculium ryckholti* (Normand), *Pisidium liljeborgii* Clessin, and the water beetles *Haliplus longulus* Le Conte, *Colymbetes rugipennis* Sharp, *Laccornis conoideus* Le Conte, *Hyroporus despectus* Sharp, *Hydrobius fuscipes* L., *Hygrotus ? turbidus* Le Conte, *Hydrochus currani* Brown, *Helophorus nitidules* Le Conte, and *Enochrus hamiltoni* (Auct).

From another slough of this type were dredged several larvae of the salamander *Triturus granulosus*. The red-legged frog *Rana aurora* inhabited most of these ponds. Two other frogs *Rana pretiosa, Rana sylvatica* were found, less commonly, in several meadows.

What I have called the forest ponds are of a different type, viz.: small depressions in the woods, screened by high willows and other tall shrubs, where small areas of water are encircled, and as summer advances, partly obscured, by sedges and other plants. They contain an abundant animal life including leeches, the molluscs *Stagnicola palustris nuttalliana* (Lea), *Helisoma subcrenatum* Carpenter, and numerous insect larvae. From one the following species of water beetles were taken: *Hygrotus sayi* J. Balfour-Brown, *Hydroporus despectus* Sharp, *Hydroporus fuscipennis* Schaum, *Agapus phaeopterus* Kirby, *Hydrochus squamifer* Le Conte, *Hydrobius fuscipes* L. and *Enochrus hamiltoni* (Auct).

BIRD MIGRATION, 1945

SPRING.—Zero temperature was recorded at Vanderhoof on April 7 and 8; milder weather prevailed during the following three weeks and patches of open water appeared in the Nechaco River. Most of the ice went out of the river about April 28 but the islands and parts of the shore were still ice-covered on May 1, and ice still drifted down the river. Shallow ponds and sloughs were open on that date but the larger lakes, Nulki, Tachick, Sinkut, still were frozen. On May 2, the first warm day of spring, ice-free channels

appeared along the east shore of Nulki Lake; on the following day a strong, westerly wind drove loose ice into these openings and they froze over during the night. In the morning of May 6 the only ice visible was in Middle Bay (Fig. 10) and by nightfall this had disappeared. Tachick Lake was still partly frozen on May 7.

A few Canada geese and mallard arrived on the Nechaco River on March 25 but all left again during the cold weather in early April. Small flocks of Canada geese were again seen, flying north, on April 10, and on this date also whistling swans were observed on the Nautley River, the outlet of Fraser Lake. Canada geese and mallard again appared in the openings on the Nechaco River on April 11. Subsequently the migration of the three species mentioned continued in increasing volume, and relatively large flocks of lesser snow goose appeared. The period of April 24 to 26 seems to have seen the peak of the Canada goose, snow goose and mallard movement. None of the observers, who supplied the above information, mentioned pintail as being a conspicuous element of the migration.

When I arrived at Vanderhoof on May 1 transient whistling swan, Canada goose, cackling goose and mallard were still present; the migration continued in diminishing volume for the following 10 days — the last whistling swans being recorded on May 2, the last Canada goose on May 6, and the last cackling goose on May 4.

On May 1 and 2 large flocks of diving ducks, accompanied by numerous Holboell grebe and baldpate, congregated on the Nechaco River and in the ice-free portions of Nulki Lake and Sinkut Lake. The composition of several congregations of flocks, examined at fairly close range, was approximately: Holboell grebe, 2 per cent; baldpate, 10 per cent; canvas-back, 10 per cent; scaup duck sp., 60 per cent; American golden-eye, 3 per cent; buffle-head, 10 per cent; surf scoter, 5 per cent. The composition of some flocks, far out on the lakes, was not determined. The total of all ducks observed on May 2 was 6000±.

At Nulki Lake, May 3, no open water was visible — and large numbers of ducks rested on the ice — as far out on the lake as could be brought into focus with 6X binoculars. Small flocks flew back and forth along the ice-covered shore.

During the week following, May 4 to 10, the flocks decreased in size, and altered in composition, and by May 26 the migration seemed to be definitely over. It was not possible to count the transient waterfowl population frequenting Nulki Lake at this time because the greater part of the lake is a feeding ground and birds move freely from place to place. The most that could be accomplished was to count the numbers on a limited area, thus sampling the migration, as its pattern altered from day to day. This was done, when visibility permitted, on that portion of the lake from, and including, Middle Bay to Nool Island — an area approximately one mile by one-half mile.

Manson's Slough and Bradley's Slough also attracted numbers of ducks at this time. A large migratory movement was noted, but not in detail, at Tachick Lake.

The wader migration was of slight importance, Wilson snipe and pectoral sandpiper being the species recorded in largest numbers; the principal migration of the first took place during the period May 2 to 6, that of pectoral sandpiper was more protracted. Species, dates and numbers of individuals observed follow:

Wilson Snipe .....May 2— 4, May 5—45, May 6—20.
Greater Yellow-legs ...May 2—10, May 6— 2, May 8—10.
Pectoral Sandpiper ...May 5—30, May 6—20, May 9— 4, May 22—6.
Least Sandpiper .....May 5— 1.
Solitary Sandpiper ...May 5— 4, May 6— 4, May 8— 2, May 9—1, May 16—1.
Wilson Phalarope .....May 27— 1.
Northern Phalarope ...June 18— 2, June 20—2.

The first black terns arrived on May 22 and were plentiful on May 27 when 80 were counted.

When I first visited Nulki Lake, May 2, the following transient and summer-visitant land birds were present, viz.: marsh hawk, bald eagle, yellow-shafted flicker, red-breasted sapsucker, tree swallow, mountain bluebird, American robin, American pipit, ruby-crowned kinglet, Audubon warbler, American crow, white-crowned sparrow, song sparrow. The first cliff swallows and savannah sparrows appeared on May 3 — a cool, cloudy day. Horned larks were first observed on May 4; the following day Audubon warblers, ruby-crowned kinglets and white-crowned sparrows were plentiful, and the first Wilson warbler was recorded.

The period May 6 to 18 was cool and showery with northerly winds; on several nights the temperature dropped below freezing; the period May 19 to 25 was one of higher temperature and less wind.

The migration continued, with one or more new arrivals noted nearly every day until May 26. This was the first day of spring weather and clear sky; thereafter the temperature rose and on May 28 reached a maximum of 76°. Then came a week in which few transients passed through. The clear, warm spell of late May continued until the last day of the month; it was followed by a succession of cloudy days with westerly winds, lower temperatures and intermittent rains that lasted until June 30. There were many days when adverse weather conditions made field observations impossible; cold, westerly winds blew continually and Nulki Lake was more often rough than calm. Another, smaller wave of transients appeared; American redstart on June 5, nighthawk on June 6 and black swift on June 10; the last arrival to be recorded was the cedar waxwing on June 21.

Excepting black swift, American pipit, horned lark, cliff swallow, rough-winged swallow, chipping sparrow and white-crowned sparrow the numbers of each species recorded from day to day was not large; on this wide plain the migratory wave would seem to be spread over a large territory. It is of interest to note the times of arrival of certain species, as indicated by the 1945 records, in comparison with the times of arrival as observed at points farther to the south. To bring out these comparisons a migration schedule

has been prepared (Table 2). In it are tabulated the dates of the first arrivals of some common species as recorded at Nulki Lake, 1945, at Puntchesakut Lake (79 miles S.E.) in 1944, at Lac la Hache (165 miles S.E.) chiefly in 1943, and at Okanagan Landing (345 miles S.E.). For the last locality average dates of arrival have been selected from a number of records. It is recognized that the value of these data is reduced because they do not refer to a single year's observation at all four localities. Various factors, perhaps, might retard the migration one year; other factors might tend to accelerate it another year. Nevertheless in spite of this obvious fault the record may have some significance. It will be observed that in general the dates of arrival become progressively later from south to north; that for several species the dates are remarkably close together, and that for one species, the cowbird, the date of arrival at Nulki Lake, May 11, is actually earlier than the date recorded for Okanagan Landing. May 16 is the earliest date of first arrival in eight years' records at that place; for five of these years May 23 is the earliest date. If these observations reflect the true facts of the cowbird migration their interpretation suggests that the cowbird enters Central British Columbia by way of a migration through the Rocky Mountains, not by way of the interior valley route.

TABLE 2.—Dates of first recorded arrival of certain spring transients.

	Nulki Lake 53° 124° N.E. 1945	Puntchesakut Lake 53° 122° N.W. 1944	Lac la Hache 51° 121° N.E. chiefly 1943	Okanagan Landing 50° 119° S E. average dates
Sora	May 19	May 16	May 2	—
Spotted Sandpiper	May 24	May 14	Apr. 30	—
Bonaparte Gull	May 2	May 6	Apr. 30	May 3
Black Tern	May 22	May 23	May 23	—
Nighthawk	Jun. 6	Jun. 6	May 28	Jun. 5
Rufous Hummingbird	May 9	May 5	Apr. 26	—
Hammond Flycatcher	May 16	May 8	Apr. 30	Apr. 30
Western Wood Pewee	May 19	May 11	—	May 16
Barn Swallow	May 22	May 17	May 20	May 14
Hermit Thrush	May 5	May 6	May 9	—
American Pipit	May 3	May 6	Apr. 29	Apr. 23
Warbling Vireo	May 25	May 18	May 10	May 12
Orange-Crowned Warbler	May 8	May 8	May 8	May 1
Yellow Warbler	May 22	—	May 15	May 11
Myrtle Warbler	May 12	—	May 11	—
Yellow-throat	May 24	May 31	May 30	May 19
Wilson Warbler	May 5	May 8	May 2	—
Cowbird	May 11	—	May 14	May 16
Western Tanager	May 19	May 19	—	May 9
Purple Finch	May 8	May 9	—	—
Savannah Sparrow	May 2	May 8	Apr. 30	Apr. 23
Vesper Sparrow	May 13	—	May 2	Apr. 22
Chipping Sparrow	May 17	—	Apr. 30	Apr. 28

AUTUMN.—Transient pintail, south-bound, first appeared on August 20 when 60 were counted on Middle Bay; other later counts were: August 22 — 250±; August 28 — 150±; August 31 — 100±. Flocks of mallard and baldpate seen at that time were considered to represent local concentrations of post-breeding adults and young, rather than the first wave of a south-bound migration, as the pintail certainly were. Cackling goose, 50±, appeared on the Nechaco River, August 29, and about the same number were seen there on September 1.

Little is known about the post-breeding, autumn migration of adult waders that precedes the migration of young. So far as known, few south-bound adult waders have been collected, or observed, in the interior of British Columbia. It is, therefore, of interest to report that a small migration of adults was observed during July and early August in the Lakes District. Species arrived in the order and in the numbers as noted below.

Greater Yellow-legs	June	29— 1, July 1— 1, July 19— 1.
Least Sandpiper	July	11— 3, July 16— 5, July 18— 1,
	July	19— 1.
Long-billed Dowitcher	July	14—22, July 16— 3, July 20—14,
	July	22— 2, July 28— 1, July 31— 6.
Semipalmated Sandpiper	July	16— 8, July 24— 2.
Pectoral Sandpiper	August	2— 2.
Black Turnstone	August	29— 1.

The migration of the year's young was of greater volume, the first species to be recorded being lesser yellow-legs (five) on July 10. Other young of this species were seen almost daily until August 31; twenty-two was the largest number counted in one day — August 4. The next species observed was greater yellow-legs — one on July 16; a small migration continued, 10 being the largest number counted in one day, and the last was recorded on August 28. Wilson phalarope was the third species noted, the first on July 20, others until August 6; the largest number seen in one day was 11 on July 24. Solitary sandpiper, least sandpiper and semipalmated sandpiper were first observed on July 31. Solitary sandpipers were seen occasionally until August 24, the largest number (four) on August 2; least sandpipers, in small numbers, continued to pass through until August 31, twenty on August 5, twenty on August 8 being the maximum counts in one day; semipalmated sandpipers also were seen until August 31, eight, on August 5, being the largest count. The first Wilson snipe was observed August 16; the species was not recorded again until August 29 when five were seen. Pectoral sandpiper, one on August 31, was the last species noted.

A migration of small land birds, chiefly adults, was first detected after July 15. It was perceptible only by the appearance of a few individuals, and in areas where the resident population came under frequent review these individuals sometimes were easily identified as transients. At the same time some of the local, nesting population commenced to move out. This movement (of the local population) became more apparent in early August when familiar bird-territories were found deserted. No birds sang and at times

few were seen. Yellow-shafted flicker, red-breasted sapsucker, hermit thrush, Swainson thrush, ruby-crowned kinglet, and other elements of the nesting population, conspicuous earlier by reason of behavior or voice, had gone. On August 15, the woods, the grasslands, and the willow swamps, almost emptied of birds, were oppressively silent. It seemed as though all the nesting birds except some sparrows had left. On that day a few Audubon warblers, Tennessee warblers and Oregon juncos were the only transients recorded. On August 16, a day of strong west wind and lower temperature, these several habitats again were occupied. For the remainder of the month the migration proceeded, in varying degrees of volume, through days of clear, warm weather and light winds. The order of arrival, from the earliest indication of migration until I left the district in early September, was somewhat as follows:

July 16—Western Tanager, adults.
July 20—Magnolia Warbler, adults.
July 22—Red-wing Blackbirds, adults and young.
July 31—American Redstart, adults.
Aug. 2—Audubon Warbler, Water Thrush, young.
Aug. 7—American Redstart, young.
Aug. 8—Rusty Blackbird, adults and young.
Aug. 10—Nighthawk.
Aug. 14—Warbling Vireo, young.
Aug. 15—Oregon Junco, Purple Finch, Tennessee Warbler, young.
Aug. 16—American Robin, adults, Western Wood Pewee, young.
Aug. 17—Western Tanager, young; American Pipit.
Aug. 18—Tree Swallow, Barn Swallow.
Aug. 20—Brewer Blackbird, adults and young.
Aug. 21—Yellow-shafted Flicker, Alder Flycatcher, Yellow-headed Blackbird, Lincoln Sparrow.
Aug. 22—Say Phoebe, Swainson Thrush, Orange-crowned Warbler, Yellow-throat, young.
Aug. 23—White-crowned Sparrow, adults and young.
Aug. 24—White-throated Sparrow, adults and young.
Aug. 26—Yellow Warbler, young.
Aug. 27—Black-poll Warbler, Savannah Sparrow, young.
Aug. 28—Horned Lark.
Aug. 29—Evening Grosbeak.
Aug. 30—Macgillivray Warbler.
Aug. 31—Wright Flycatcher.
Sept. 1—Hammond Flycatcher, Cliff Swallow, Barn Swallow.
Sept. 2—Red-eyed Vireo.

POST-NESTING CONCENTRATIONS OF DUCKS

The first evidence of post-nesting concentration of ducks on a large scale was noted near the west end of Tachick Lake on July 4, when approximately 80 baldpate and 40 redhead, chiefly males, were associated with about 100 lesser scaup ducks, chiefly non-breeding yearlings. About these same numbers were counted again on July 12; relatively few were seen in subsequent visits.

The most notable concentration took place on Nulki Lake near the entrance to Middle Bay. Ducks were first seen there in numbers early in the morning of July 15, after a 36 hour blow from the west followed by an east wind and showers. The association consisted of six species in the following

estimated numbers, viz.: mallard, 200; baldpate, 100; redhead, 20; lesser scaup duck, 50; golden-eye sp., 40; buffle-head, 30. Ducks of several species continued to associate on this area until the middle of August. The total of ducks, and the numbers of each species, fluctuated from day to day. Mallard were not seen amongst the diving ducks after July 19; baldpate almost invariably formed part of the raft.

All these ducks were very wild. Usually they kept well out from shore and it proved impossible to approach them closely in a canoe. When this was attempted the ducks rose, one flock after another, and, after circling high in the air a number of times, left the bay. They always came back, sometimes to form a long line on the open lake, sometimes to spread out over a large area rarely less than one-half mile from shore. Identification by distant observation through binoculars usually was difficult because of rain or wind; on July 17 I counted a total of 780 ducks but was unable to distinguish the species satisfactorily. Occasionally a segment of the raft drifted close to the south shore of Middle Bay and fed there. Thus on July 20 some members of a large flock came in and I was able to approach them close enough to see that a few were ring-necked ducks, the majority yearling golden-eye sp. and lesser scaup ducks. The association increased to about 1000 on July 24; afterwards it declined in size until on July 31 not more than 300, and on August 13 not more than 100, were present. These were chiefly lesser scaup duck. By August 15 the last ducks comprising this association were gone.

Probably the diving ducks and the baldpate forming this continued association renewed their flight feathers during the time they remained there, but of this I obtained no proof. Lesser scaup duck, about 300, were flying well on August 5; presumably they had finished the moult. No flightless ducks were seen on the water at any time but it is probable that birds in a flightless condition escaped detection by reason of the poor visibility that generally prevailed.

On August 20 the post-breeding mallard, baldpate and pintail were first seen in numbers, this being on Middle Bay close to the north shore where the ducks gathered to feed. The first two species were thought to represent a local population; the pintail obviously were transients as none was found nesting in the region. Subsequently ducks of these species concentrated on Bradley's Slough. Flushed from there they rose in small flocks, and, after circling the slough made off in the direction of Nulki Lake. Counts made at Bradley's Slough during the remainder of August follow:

1945	*Mallard*	*Pintail*	*Baldpate*
August 15	40	60	10
August 22	75	250	200
August 23	100	—	200
August 31	200	100	400

A similar concentration took place in August, 1946.

Loss of Young Ducks on Nesting Grounds

A total of 11 downy ducks was found dead between June 28 and July 18, the species and numbers of each being: blue-winged teal — 5, redhead — 1,

Barrow golden-eye — 4, buffle-head — 1. All but two, the redhead and a blue-winged teal, were found on Bradley's Slough. Seven showed no marks of injury; one was too much decomposed to admit of examination, the three others obviously had died as a result of wounds. A golden-eye, about 10 days old, was punctured in the back close to the spine — the type of wound that could be made by a hawk's talons. A blue-winged teal, several days old, had a large cut on the side of the head; another had abrasions on the same area. Neither loons nor grebe frequented the slough at this time but two pairs of coots were there at the time the young ducks were killed. At no time was a coot observed harassing other waterfowl.

SUBCUTANEOUS INFESTATION OF PASSERINE BIRDS BY PROTOCALLIPHORA

Evidence of the killing of fledgling passerine birds by a fly maggot *Protocalliphora hirudo hirudo* S. and D., feeding subcutaneously, was obtained first on June 23, 1945. Later it became clear, by the number of nestlings found dead, or in a dying condition, and by other observations, that the insect concerned was abundant, and the mortality amongst young birds of certain species caused by them of serious proportions — perhaps as much as 75 per cent of the total population. Unfortunately this condition was not understood until late in the nesting season, so only a preliminary investigation of the problem was possible.

The life-history of the blood-sucking maggots of *Protocalliphora* appears to be well-known; much has been written about it. The life-history of *Protocalliphora* maggots which feed subcutaneously is not so well understood. Professor Geo. Spencer of the Department of Zoology, University of British Columbia, advised me (personal letter, July 8, 1945) that its history in Canada is unknown and that specimens are greatly desired by entomologists. Professor Spencer stated further that in 1925 an infestation occurred in brooder chicks in Vancouver, British Columbia, and in 1938 the embryologist at the University of Washington, Seattle, Washington, investigated a similar condition and reared adult flies from puparia.

In 1939 Guberlet and Holson (1940) found *Protocalliphora* maggots infesting a young nestling English sparrow *Passer domesticus* at Seattle, Washington; immediately following the death of this bird on May 19, 1939, twenty-one maggots were removed alive from the skin and subcutaneous tissue — "The death of the bird was unquestionably due to this infestation." Flies raised from the maggots were identified, by C. H. Curran, American Museum of Natural History, as *Protocalliphora splendida hesperis* Shannon and Dobroscky. This is the only reference in literature I have been able to find.

My observations, and assumptions from them, suggest that the flies deposit eggs (or perhaps minute larvae) on newly hatched nestlings; the larvae bore through the bird's skin and follow its inner surface over all parts of the body. The presence of maggots could not be determined by external examination of the host prior to the time it left the nest. In about seven

days the larvae attain a length of 8 to 10 millimeters. The young bird, by that time about one-third grown, becomes irritated by the presence of the feeding larvae to such an extent that it struggles out of the nest and drops to the ground; the larvae then emerge, burrow into the earth and pupate. It would seem that, in order to pupate, larvae must have access to the soil. The young birds leave the nest at the precise time in the life of the larvae when this development is ready to take place. That seems to be the normal course of events; sometimes, however, the young die in the nest. No puparia were found in a careful examination of two nests which had contained infested birds.

In some of the instances under observation the relatively helpless young after leaving the nest were devoured by ants, which clustered on all parts of their bodies in such numbers as to completely cover them. This process — the sudden departure of the young from the nest, the quick emergence of the maggots, the consumption of the birds by ants — renders the securing of specimens of *Protocalliphora* a difficult matter. Success in doing so is largely governed by chance. However, a total of 30 puparia was secured from several infested birds. The birds were killed, then placed in a jar containing moist earth. The larvae commenced to emerge immediately and burrowed into the earth. Half of the resulting puparia were sent to Professor Spencer, the others, retained for personal observation, emerged as adults in 27 days.

The details of field observations of nests and young birds are summarized below.

SONG SPARROW

1. A nest found June 12 contained four song sparrow eggs and two cowbird eggs; the last hatched on June 14; the first were all hatched by June 18. On June 22 one song sparrow was missing. The remaining nestlings left the nest when I touched it. All were captured and returned to the nest but became passive only after I had covered them with my hand for several minutes. The following morning the nest contained one dead cowbird and one live song sparrow. On the ground close by were the second cowbird and another song sparrow; the first was dead, its abdomen nearly covered with fly maggots, the largest 8 millimeters long; the second was in a dying condition. The third song sparrow was not found. Dissection of the dead cowbird and the two song sparrows showed that in each were numerous maggots under the skin, on the abdomen, the sides and the crown; some were protruding from holes in the skin.

2. This nest, when found on June 28, contained four song sparrow eggs and one newly-hatched cowbird; all the eggs were hatched by July 1. On July 3 one song sparrow was dead in the nest. On July 7 the remaining nestlings, viz, three song sparrows, one cowbird, were dead on the ground close to the nest, all partly eaten by ants. Two fly maggots were recovered from outside the skin of one bird; none emerged from the half-eaten bodies after being placed on moist sand. Possibly ants had eaten them as they emerged.

3. This nest contained four eggs on July 2 and all had hatched by July 8. On July 16 when the nest was approached three young fluttered out and were not recovered. The fourth nestling, smaller than the others, was dead in the nest the following morning. This bird contained numerous small fly maggots all of which died after being placed on moist soil.

4. Nest number 4 contained four eggs on July 3, and four well-grown young on July

12. The following day two young, partly eaten by ants, were on the ground; the other two were not found. The presence of fly maggots, considered probable, was not proved.

SAVANNAH SPARROW

5. On June 27 a half-grown fledgling, attended by parents, that flushed from the grass was captured after it had flown a few yards. On being handled several large fly maggots dropped from its feathers. Later, while it was under observation, two others emerged and crawled into the flank feathers. When this bird was skinned it could be seen that one maggot had emerged through the skin above the knee, another through the skin over the breast, a third through the crown and a fourth through a nostril.

6. On June 29 a fledgling, half-grown and capable of only short flights, was captured in a patch of weeds. This bird proved to be in poor condition, without fat. At the base of the bill was an aperture, surrounded by dried suppuration, through which, it seemed likely, a *Protocalliphora* maggot had emerged. The gullet of this bird contained nine adult flies, Tachinidae.

AMERICAN ROBIN

7. On July 8 a robin's nest contained three eggs, and, on July 16 three young. On July 25 the nest was empty and one dead young hung from a twig below it. In the skin of the abdomen and in the skin on the crown were single apertures from which *Protocalliphora* maggots evidently had emerged.

YELLOW WARBLER

8. A nest under observation contained a clutch of five eggs on June 17; all had hatched by June 27, and on July 7 the nest was empty. On July 9 one fledgling, attended by the female parent, was found on the ground about 20 yards from the nest. It was less than half-grown and could not rise from the ground in flight. A lump on the carpus indicated the presence of *Protocalliphora* larvae. When the bird was killed, and placed on damp sand, larvae commenced to emerge immediately; a total of 11 was recovered.

CLIFF SWALLOW

9. On July 16 a nest containing four young fell from the roof of a barn. It was observed that each of the young, all of which were dead, had fly larvae emerging from the skin about the head. This observation was made by Mr. George Evans.

BANK SWALLOW

10. In early July a half-grown swallow, probably of this species, found dead under a bank in which were numerous nests, had a fly larvae attached to one wing. This observation was made by Mr. Einar Lynum.

PURPLE FINCH

11. A purple finch's nest on the ground in a willow clump, which had been visited several times previously, contained three dead, partly-fledged young, and one egg. The nest was filled to its brim with ants and the birds were partly consumed. The presence of *Protocalliphora* was suspected but not verified.

The above is the sum of this particular type of evidence; other observations, however, are believed to be significant. Thus the year's crop of passerine birds seemed extremely small; in July adults were much more plentiful than young. Birds of various species were observed feeding and attending one young only, instead of the usual two or three. Until July 21 not a single young robin, a species usually conspicuous, was observed. Two colonies of red-wing blackbird under observation, one of nine pairs, the other of six pairs, produced a total of less than eight flying young; that this species nested successfully elsewhere was evinced by the large percentage of young in migrating flocks which appeared in late summer. Flocks of Brewer blackbirds that commenced to

visit the fields in mid-July were composed largely of adults; in other years, elsewhere, it has been observed that the number of young of this species was at least equal to the number of adults. Colonies of rough-winged swallow and bank swallow apparently raised no young to maturity, neither did Tennessee Warbler, American redstart, nor yellow-throat.

It is not known whether or not any of the maggot-infested young survive. In the hope of obtaining information on this point a total of twelve flying young comprising red-breasted sapsucker, hairy woodpecker, alder flycatcher, red-wing blackbird, Audubon warbler, water thrush, warbling vireo and song sparrow were collected. None showed the characteristic punctures made by *Protocalliphora* maggots when emerging, and obviously none had been parasitized.

In 1946 special attention was again directed towards this problem. Nine nests of small land birds were kept under observation, and a number of fledgling and juvenile birds were collected for examination. No indication of nestlings being parasitized was detected amongst those examined in nests, and of the 12 flying young collected only two contained *Protocalliphora* larvae. These were Townsend solitaires taken on June 23, and probably belonging to one brood.

However, there was evidence of how effective the 1945 outbreak had been in reducing the numbers of certain passerine birds. Thus the song sparrow population, perhaps the chief victim, was reduced by an estimated 75 per cent. Many territories occupied in 1945 were vacant; others had been pre-empted by white-throated sparrows — a species whose numbers had increased substantially. The nesting populations of American robin, cliff swallow and savannah sparrow were smaller and no yellow warblers were observed.

BERRIES AS FOOD FOR BIRDS

The large, glistening-black and slightly sweet fruit of black twin-berry is the berry most attractive to birds in the Vanderhoof region. This shrub grows abundantly in forest clearings, on open hillsides, in burns, on lake margins, and amongst willow thickets in the lowland swamps. Song sparrows feed the berries to their young to such an extent that nests are stained purple by the voided debris. The species of birds known to have fed on the berries are: ruffled grouse, yellow-shafted flicker, red-breasted sapsucker, hairy woodpecker, eastern kingbird, American robin, hermit thrush, olive-backed thrush, Tennessee warbler, Audubon warbler, cedar waxwing, purple finch, white-crowned sparrow, white-throated sparrow and song sparrow. This was determined partly by the observation of birds feeding, partly through examination of the digestive tracts of birds collected. In some specimens thus examined the skin about the bill and the throat was stained with berry juice. Undoubtedly many more species than those listed feed upon black twin-berry.

Service berry is common and widely distributed; at Nulki Lake it grows abundantly; indeed at no other place have I found it in such profusion. The fruit is locally of economic importance; Indians dry large quantities for use in winter; white settlers can them and make them into jam. For both Indians

and whites the berries provide a welcome fruit diet in summer; people from miles around come to Nulki Lake to gather the berries, which in 1945 at least, ripened in enormous numbers. It was expected that this abundant fruit-crop would attract many kinds of birds but nothing of the kind was observed. In 1945 no birds were seen feeding on service berries and in only one specimen, an Swainson thrush, were remains of the berry detected. In 1946 a robin and a flock of cedar waxwings were observed feeding on the fruit.

Soopolallie also is widely distributed, but most of the attractive crimson-colored, waxy fruits remained untouched on the bushes, so far as birds are concerned. A robin carrying this fruit to feed young in the nest was the only observed instance of its use by birds.

Another plentiful fruit is the white berry of western dogwood. Although birds have been observed in other parts of British Columbia eating this fruit none was seen doing so in the Vanderhoof region. Choke-cherries blossomed heavily but produced little or no fruit.

It would seem that the birds' preference for black twin-berry is so decided, and the supply of this food so plentiful, that other fruits are neglected.

DESCRIPTION OF OTHER LOCALITIES VISITED

THE NECHACO RIVER NEAR VANDERHOOF

A three-mile section of the Nechaco River above Vanderhoof was established in 1944 as a Federal Bird Sanctuary. This portion of the river contains several wooded islands and, at low water, numerous gravel-bars to which whistling swans, geese and ducks resort in numbers. The gravel-bars were ice-covered on May 1. The annual high floods in June make the river unsuitable as a nesting ground for waterfowl, although mallards are reported to nest on the meadows adjacent to it. However, even during high water, some ducks rest and feed on the sanctuary. Thus on May 28 a few mallard, baldpate and blue-winged teal, and in early June a flock of 40 to 50 post-breeding mallard drakes, were observed on the wide, swollen river. On August 29 the following were counted on the gravel bars and the water, viz.: Canada goose — 30, cackling goose — 50, mallard — 30, baldpate — 10, green-winged teal — 15.

STUART LAKE AND TACHIE RIVER

Through the courtesy of Mr. Robert Howe, Indian Agent, I was privileged to visit Stuart Lake and Tachie River in the departmental gasboat. We left Fort St. James, at the east end of Stuart Lake, in the morning of July 26; reached the mouth of Tachie River at 2:00 p.m., and, piloted by an Indian, Peter Seymour, proceeded up river to Grand Rapids. On the return trip down river we reached Tachie at 7:30 p.m., and tied up for the night at an adjacent island. The following morning we continued up the lake to Stuart Portage and in the evening returned to Fort St. James.

Stuart Lake.—Stuart Lake, 48 miles long, 1 to 5½ miles wide, is a deep lake in mountainous country. The shore line along the eastern portion of the north side is characterized by high, rocky slopes, covered with scrubby

Douglas fir, and bare cliffs sheer to the water for several hundred feet. Far up on the face of one cliff are small, shallow caves that seem perfectly adapted to the nesting requirements of golden eagle, duck hawk or horned owl, but no examples of these species were observed there. Farther west the cliffs are lower. At one place, about seven miles west of Fort St. James, an area of 10 to 12 square feet of rock surface is covered with pictographs, said to be very old. The present generation of Indians have no knowledge nor tradition of their history.

The prevailing forest types along the north shore west to Pinchi Creek is Douglas fir on the rocky slopes and Engelmann spruce and aspens elsewhere. West of Pinchi Creek the mountains lie several miles back; the land near the lake flattens to benches and here aspen is dominant. This condition also prevails still farther west where the lake narrows and the hills in the background are lower and rounded. Here Douglas fir occurs in small stands, chiefly on ridges; white birch and cottonwood are fairly plentiful; lodgepole pine is scarce near the lake. On the south shore much of the slopes have been burned over and are now covered with aspen. Along the east shore the land rises in low benches and the forest on them is composed of small Engelmann spruce and aspen.

Numerous islands, the majority in groups, ranging in size from a fraction of an acre to several of a mile or more in length, are conspicuous in the topography. Some have bare rock cliffs above the shore line — the best example of this type being Battleship Island near the east end of the lake. In general the shore line of the larger islands resembles that of the mainland. Some of the smallest islands carry only scattered deciduous growth, the larger ones are treed, principally with Douglas fir. One island, beside which we tied up for the night, is characterized by a number of unusually tall Douglas fir and cottonwood. Here also are several stunted western red cedar, *Juniperus occidentalis*, one being 12 inches in diameter at the base; highbush cranberry is conspicuous amongst the shrubbery. Close to one group of islands are several rocky reefs with low vegetation showing green amongst the boulders. Another, about a mile off the mouth of Tachie River, supports a small amount of deciduous tree growth; this and several other reefs, or islets, were occupied by adult herring gulls.

At the mouth of Tachie River a low, flat point is covered with marsh-growth; several bays in the northern portion of the lake, the largest at Stuart Portage, also have shore-marshes composed chiefly of horsetail. None can be regarded as an important nesting ground for waterfowl; geese and ducks are reported to visit them during migration.

Approximately 30 herring gulls and six loons represent the total of water birds seen during two days travel on the lake.

Tachie River.—Tachie River enters Stuart Lake on the north side about 32 miles west of Fort St. James. At the mouth, on the west side of the river, is a large meadow from which a marshy point extends several hundred yards into shallow water. A trading post is located here; opposite, on the east side of the river, is Tachie Indian Village. For about two and one-half

miles upstream the current is not strong in the wide channel of 150 yards more or less. The littoral growth is chiefly aspen and willow with small marshy fringes of horsetail and sedges. In one place, where the river widens, is a more extensive marsh, and pondweeds grow thickly in the shallows. Above, fairly fast water is general, and shore line marshes are restricted to relatively quiet reaches. The river narrows and widens in a succession of short rapids and longer stretches of deep water with a swift current. Grand Rapids, 10 airline miles from the river mouth, is three-quarters of a mile long, and the roughest of the fast water. At the head of the rapids the river widens to 200 yards or more and the forest opens to small areas of grasslands; here is the small Indian reserve of Grand Rapids.

The bird life seen on the river consisted of three American merganser, four adult bald eagle, two spotted sandpipers and one kingfisher. Geese and ducks are reported to frequent the marsh and the shallows at the river mouth during migration.

STUART RIVER

Stuart River, 68 miles long, drains Stuart Lake into the Nechaco River. Below the outlet at Stuart Lake, and above the mouth at the Nechaco River, are stretches of fast water; between these shallows and rocky reaches, for a distance of some 40 miles, the river is deeper with only a slight current. On June 29 I travelled, by river boat, 16 miles up river from the Webber Lake Road. The water was high with the spring flood that had only commenced to recede; the river bed — about 50 yards wide at the starting point and for a mile or so upstream — was full from shore to shore. Forest of white birch, lodge-pole pine, clean, straight aspen and Engelmann spruce cover the slopes on either side; along the river-margin cottonwood, aspen and willows predominate. Two miles upstream the river widens to 100 yards and more, narrows, and again widens. At intervals are high cut-banks that through the years have restricted any inland invasion of the river (Fig. 18). At other points the banks are low and the river floods willow swamp and sedge meadows Some of the last are 50 to 75 yards wide, and continuous for half a mile or so. Several are fringed with tall river grass and reed grass, and I observed one small bed of round-stem bulrush. In several low places narrow backwaters lead to willow and alder thickets.

Sixteen miles up river the channel, at high water, widens to about 200 yards and in the center of the river is a small sedge-and-grass-covered island — its top, at the highest point, about five feet above the water at spring flood level. I was informed that above the island, for 10 miles or so, numerous gravel bars show at low water. This section of the river is a resort for goose hunters.

Stuart River appears to have little value as a nesting ground. The only waterfowl seen were: one Barrow golden-eye, five American merganser and one hooded merganser with brood.

CLUCULZ LAKE

Cluculz Lake, 11 miles long, 1/3 to 1 mile wide, situated about 18 miles southeast of Vanderhoof, was not studied in detail. It is a generally deep

lake with timbered shores, and contains a fish population similar to that of Nulki Lake (see page 20) with the addition of lake trout *Cristivomer namaycush,* and sculpin *Cottus asper.* There is a shallow, marshy area at the west end, another in a large, partly landlocked bay on the north side. From this bay the lake is drained through Cluculz Creek to the Nechaco River about six airline miles distant. Loons, Holboell grebe, several species of ducks, and black terns are reported to nest beside this lake.

ANNOTATED LIST OF BIRDS

Gavia immer (Brunnich), Loon.—Not common in the Lakes District. On May 2 two were observed on an area of open water in Nulki Lake that otherwise was still covered by ice. These, or two others, were recorded at intervals during the summer on different parts of the lake, or were heard in flight. Apparently only one pair was on the lake; I obtained no evidence of nesting. One adult was recorded on Tachick Lake, July 1, and again on July 12. On Stuart Lake, July 26 and 27, during approximately 100 miles travel by boat the total counted was 10, of which six were in pairs. No young were seen.

Colymbus grisegena Boddaert, Holboell Grebe.—This was the commonest grebe during the spring migration. On the Nechaco River near Vanderhoof, May 1 and 2, some accompanied flocks of diving ducks that rested there, others were by themselves in small flocks, and one group of seven was asleep on the water. On May 4, at Nulki Lake, a loud chorus of grebe voices came from the open water at dusk, and at Tachick Lake, May 7, these grebe were plentiful and noisy; one flock contained 68 individuals, and many others, totalling an estimated 200, were scattered over the lake.

At least nine pairs nested on Nulki Lake. Five typical floating nests in a horsetail and round-stem bulrush marsh, situated on the south shore a half-mile west of South Bay, were examined on May 26; at this time the horsetail had commenced to show above the surface; no green showed in the bulrush beds. Thus all nests, lacking concealing cover, were in plain view. Two, constructed of horsetail, chiefly the previous year's growth, contained three eggs each; one clutch was covered, the others exposed. Three nests, made of old, round-stem bulrush, were empty. The parent birds loafed on open water, 100 yards or more from the nests while these were being examined. The total population as counted on July 24 consisted of 16 adults and 12 young.

A population of larger proportions nested on Tachick Lake. On July 4, 24 adults and 8 young were counted there.

Two pair built nests on Bradley's Slough; one nest was soon deserted, and the pair left the slough without laying; the other nest contained one egg on June 7 and three eggs on June 23. One egg was taken, perhaps by a crow, on June 24; another was missing on June 25; the grebe then left the slough and were not seen again. Both nests, made of rotted sedge stems, were built in sedge clumps at the outer edge of the shore marsh that afforded good concealment and a solid nest foundation.

For most of the summer two pairs frequented a horsetail marsh on Sinkut Lake near the outlet of Sinkut Creek. No attempt was made to locate the nests.

On August 26 it was observed that adults and young were beginning to associate in flocks on Nulki Lake, and again, as in the spring, the birds called frequently.

In 1946 the first indication of post-nesting flocking was observed August 27 at Sinkut Lake when 10, chiefly adults, were together near the outlet of Sinkut Creek.

Colymbus auritus Linnaeus, Horned Grebe.—On May 2 one adult swam amongst a flock of diving ducks on Nulki Lake; this bird, or another, was seen there daily until May 9. On May 26 four adults, evidently paired, were observed at the same place. One pair frequented Manson's Slough, between May 22 and June 7; another was seen several times (May 28 to June 1) on Bradley's Slough. None of these was known to have nested and none was seen later in the season. The only summer records are: one on Stony Creek, July 3, another on Tachick Lake, July 4. Both were in faded breeding plumage.

Colymbus nigricollis (Brehm), Eared Grebe.—On July 8 seven nests were found in a bed of yellow pond lily, about 100 square yards in extent, some 300 yards out from the marsh on the west end of Tachick Lake. This was a relatively safe situation for floating nests; the prevailing winds are from the west and the water on this part of the lake usually is quiet. Four nests were made exclusively of green pondweeds, chiefly *Potamogeton zosteriformis* and *P. Friesii*. Two others, with pondweed bases, included a number of young pond lily leaves — so placed that the slender stems lay across the nest and the leaves formed a pattern around it (Fig. 19). The fifth nest contained three small pond lily leaves as part of its structure.

Each of five nests contained four eggs and in both the others were two eggs only. One clutch of four included a fresh, unstained egg and this clutch was not covered. All the eggs, except the single fresh one, were rendered inconspicuous by an olive-brown patina and this also gave a smoothness to the natural chalky surface. These six clutches, when discovered, were covered completely with pondweeds.

Only two of the grebe were seen, and at a distance that exceeded 100 yards. They were very wild and could not be detected after they dived the second time. The colony was visited again on July 12; this time the eggs in all the nests were covered; no grebe were seen.

On August 9, 1946, at the same place, one adult with three large young, and three other adults, were observed at close range.

Æchmophorus occidentalis (Lawrence) Western Grebe. — The first western grebe were recorded, on Nulki Lake, May 8, when 10 appeared amongst the numerous diving ducks on Middle Bay. The following day 20 were counted on the same territory. Subsequently one or two were seen or heard there daily until June 5; a single bird appeared on June 21.

At Tachick Lake, on June 4, one was observed swimming close to the edge of a round-stem bulrush marsh, and on July 12 a flock of 10 was counted at the west end of the lake. Whether or not these birds represented a nesting colony was not determined. At the east end of this lake, August 21, 1946, a total of 30, apparently all adults, was scattered on about 10 acres of lake surface which also was occupied by a mixed lot of pond ducks and diving ducks.

Podilymbus podiceps (Linnaeus), Pied-billed Grebe.—The unmistakable voice of this grebe was heard in the marshes at the west end of Tachick Lake each time that place was visited, viz.: July 4, July 8, July 12 and August 6. A specimen collected by Wm. Spreadborough, August, 1919, is in the Canadian National Museum. It was not recorded in 1946.

Pelecanus erythrorhynchos Gmelin, White Pelican.—On July 15 at 11:00 a.m. a single adult white Pelican flew east across Middle Bay at Nulki Lake. This is the only record.

Ardea herodias Linnaeus, Great Blue Heron.—On August 20 two birds of the year alighted on the beach at Middle Bay. These or others were seen there, or in the vicinity, up to the time of my departure on September 4.

Botaurus lentiginosus (Montagu), American Bittern.—Seen numerous times in most of the marshes visited throughout the summer. The first was recorded, at Tachick Lake, on May 20.

Cygnus columbianus (Ord), Whistling Swan.—The whistling swan migration probably had passed its peak when I reached Vanderhoof on May 1. On the evening of that day a flock of 21 was observed feeding along the edge of the ice which had accumulated on the shore of the Nechaco River about three miles below the village. The same number were seen in flight down river the following day. On that day also a flock of 22 appeared on Manson's Slough feeding amongst the flooded sedges, or resting on the shore. The same number was counted there at 2:30 p.m. on May 4. As I approached them none rose until I reached a point about 30 yards from the shore, and 100 yards from the nearest bird, then they began to rise a few at a time and, after making a wide circle, flew towards Nulki Lake where later some were seen asleep on the ice.

Records of the spring migration by other observers are as follows: Stuart River, April 18 — 100±; Nechaco River, May 4 — 32; May 5 — 56, May 7 — 75, reported by P. Brown; Tachie River, May 4 — 500±, reported by S. Snoski, trader at Tachie.

Several persons told me of an exceptionally large flock that landed on Middle Bay, Nulki Lake, on a November morning in 1943. This happened just before the freeze-up. Over the bay were scattered large and small flocks that totalled well up to 1000. The birds commenced to leave, 100 or more in a flock, about 4:00 p.m. of the same day and by nightfall all had gone. No such flight, I am told, was observed in the district before or since.,

Cygnus buccinator Richardson, Trumpeter Swan.—On May 5 a single trumpeter swan, a bird of the previous year, was observed asleep on the shore of Manson's Slough. It did not rise when a flock of whistling swans, scattered over the slough, took flight, but remained standing until I had

walked to a point about 150 yards from it. The bird then rose and flew across the slough and over the top of the nearby woods. On the following day at 11:00 a.m. four trumpeter swans, all young birds, stood on the edge of the slough. These seemed unusually large, even for trumpeter swans, and each head and neck was darkly stained with iron salts. I walked within about 200 yards, and then left the vicinity in order not to disturb them into flight. On May 8 at 2:30 p.m. the swans again were on the slough; three were feeding while one rested on shore. This band left the same afternoon and none was seen subsequently.

Branta canadensis (Linnaeus), Canada Goose.—Several persons in Vanderhoof told me that large flocks of Canada geese had been in the vicinity for about two weeks prior to my arrival on May 1. The first were seen April 3 and the migration reached a peak on April 25. These flocks fed morning and evening in the grain fields north of the Nechaco River and spent the daylight hours in the Nechaco Bird Sanctuary. On the evening of May 1, when feeding grounds were visited, I counted one flock of 60 and two flocks of six each. On May 4 to 6 a flock of 21 was counted on Manson's Slough.

Apparently none nested in the Lakes District; one pair that flew over Manson's Slough on June 21 represented the sole record for the summer.

A few began to frequent the Nechaco River Bird Sanctuary in the last week of August; a total of 30 was counted there on August 29.

Branta leucopareia (Brandt), Lesser Canada Goose.—A dozen or more medium-sized geese on the Nechaco River, May 2, in company with other geese of the *canadensis* type, were considered to be of this species.

Branta minima Ridgway, Cackling Goose.—Cackling geese in flocks frequented the Nechaco River at Vanderhoof both during the spring and the autumn migration. On May 2 a total of 150, and on May 4 a total of 200, were counted there — the majority on the then ice-covered islands where they stood motionless, some relaxed in sleep. Others rested on the adjacent quiet water. At the same place on August 29 a flock of 50 represented the first of the autumn migration. One group of five, apart from the others, followed a somewhat larger bird. These were thought to be a brood. About the same number, a flock of 50, was counted there again on September 1.

Anser albifrons (Scopoli), White-fronted Goose.—At Nulki Lake I found the carcass of an adult, shot during the previous autumn, and the remains of another which had been eaten on the lakeshore by some predator, perhaps a coyote. Later it was learned that a flock of 30± frequented the east end of the lake during the autumn migration of 1944. At least six had been shot from this flock.

On May 22, at Manson's Slough, three walked out of the shallow marsh to higher ground on the shore where they remained for a few moments, then rose, and, after flying twice around the slough, calling repeatedly as they did so, made off in the direction of Nulki Lake.

Chen hyperborea (Pallas), Lesser Snow Goose.—During the latter part

of April flocks of lesser snow geese frequented the Vanderhoof region and fed over the stubble fields in company with, or close to, flocks of geese of the *canadensis* type. The number present, between 300 and 400 according to Mr. P. Brown, represents the largest concentration in Central British Columbia of which I have knowledge. These flocks left before I arrived at Vanderhoof but on the evening of May 1 I counted a flock of 30 in one field. On May 6, and twice on May 7, a single bird was observed on a grassy slope above Tachick Lake.

Chen rossi (Cassin), Ross Goose.—Mr. Adam Dickson, who lives on North Bay, Nulki Lake, told me that about eight years ago, in the spring, a flock of very small white geese visited the bay. One of these alighted amongst his white fowls and remained in the vicinity, feeding daily with the fowls, for approximately one week. I have examined a photograph of this bird. Very likely these were Ross geese. It is to be noted that Roderick MacFarlane obtained a specimen of this goose at Stuart Lake, about 35 miles north of Nulki Lake, in the summer of 1889.

Anas platyrhynchos Linnaeus, Mallard.—Abundant in spring, and reported to be equally so in autumn. Nesting in small numbers throughout the region and reported as wintering on the Nechaco River in the vicinity of Vanderhoof and on the Stuart River at the point where it leaves Stuart Lake. It was reported to me by various observers that in late April "thousands" frequented the Nechaco River Bird Sanctuary in daytime and fed over the adjacent stubble fields morning and evening. The majority had left by May 1; on the evening of that date I counted 40, in company with Canada geese, on a field north of the Nechaco River.

During the next several weeks paired mallards were on most of the sloughs visited. Some were observed in courtship flight, others standing on the shores of sloughs or amongst the flooded grasses, others again in company with mixed associations of pond ducks and diving ducks. The latest date a pair was seen together was June 16.

On May 5, at Bradley's Slough, a male and female rose from the shore and circled over the lake, flying very fast. Once the male increased its speed, and, flying above the female, attempted to grasp her neck with his bill. Another male joined these two and for a few moments the trio continued flying in company. A pair nested somewhere near this slough and during the incubation period the female was seen there frequently, sometimes as she alighted, sometimes during her feeding times. On June 8 she flew in at 8:50 a.m., and on June 14 at 11:00 a.m. slanting down to the water from a height of several hundred feet. She brought her young to the slough on June 27. In the evening of that day, the first time the brood was seen, she shuffled back and forth in front of a section of shore marsh where her brood was concealed. Presently seven young emerged from the marsh and joined her; she then led them across the open water of the lake. This brood still numbered seven on July 4. In 1946 the first brood, one of nine, was recorded June 14 at Bradley's Slough; subsequently this family was observed several times. Defense behavior by the female was characterized by intense excitement during

the first 10 days or longer. Thus on June 26, when the nine young, now about two weeks old, were disturbed from the sedges on the slough margin the female rushed back and forth across the water at a maximum distance of about 30 yards from where I stood. She quacked only occasionally. The young ducks, after scampering across the water in apparent confusion for 20 yards or so, assembled in close formation and swam down the center of the slough. For 10 minutes after the brood had passed out of sight the female continued demonstrating but at a greater distance from shore. She now quacked more often and more vigorously; she made short flights, not 'rushing' as she had at first. She was not seen rejoining the brood. On July 2, under similar circumstances (the brood now being reduced to six) she acted in much the same manner, but for only a short period; she then walked on to the beach, across the slough from where I stood, and made no further demonstration.

Another pair that nested in a willow swamp at Middle Bay in 1945 was the subject of frequent observation. The nest, built under a leafed-out and blossoming twin-berry situated near the center of a dry alder-thicket in the swamp, contained three eggs, but no down, on June 1, and six eggs with a small amount of down on June 3. When next visited on June 14 the nest was deserted, the six eggs completely hidden by a sodden mass of down and sedge fragments. Subsequently this pair of mallard, or another pair, was seen frequently in or near the swamp and, it was believed, nested again, this time successfully.

In a willow thicket on Sinkut Meadows a nest was located on a dry shelf at the base of a six-inch willow stump; a prostrate willow trunk directly above it afforded shelter and partial concealment. This nest contained six eggs on June 8.

A brood of 12, about one month old, was observed at Tachick Lake on July 4. The young were led by the female along a wooded section of the shore screened by overhanging brush. As a boat approached them, the female, then each of the young in quick succession, scrambled up a steep bank by way of a narrow path through thick vegetation, and vanished into the woods. This was the largest brood recorded.

In 1945 the first evidence of post-breeding males associating was observed on June 8 when two arrived on Bradley's Slough and loafed together on open water. They remained there several days. The second observation, on June 16, concerned a flock of 16 on Stony Creek where it enters the Nechaco River, the third on July 15 when approximately 200 alighted amongst a raft of post-breeding diving ducks and baldpate on Middle Bay, Nulki Lake. These did not remain with the diving ducks beyond that day. At Tachick Lake, August 6, many adult males, some in full eclipse, were flushed from the marsh. The majority seemed to be in the process of renewing the flight feathers and rose with difficulty to fly only a short distance and then drop into the concealing marsh cover. Other adults, of both sexes, associated with diving ducks on open water. By August 20 full-grown young were plentiful. On August 23 a flock on Bradley's Slough including young,

and adults of both sexes, numbered approximately 75. On August 31 a flock of the same components totalled 200±.

In 1946 mallard commenced to gather on Bradley's Slough by mid-August, the largest numbers counted there being 600 on August 16, 500 on August 17 and 400 August 19 to 22. Baldpate and pintail frequented the slough at the same time, and towards the end of the month greatly outnumbered the mallards. On days when large numbers of ducks were present, when the slough appeared to be covered with them, or when the entire population was either rising, or milling about overhead before straightening out in direct flight, the sight was truly impressive. During their stay in the district the ducks spent part of the time on this slough and part of the time on the adjacent Nulki Lake. At the last place they sometimes assembled on fairly deep water well out from shore. Probably Bradley's Slough was their chief feeding ground. The water level had dropped so much that food could be obtained by 'dipping' on every part of it. Feeding was done mostly at night and in the early morning. The only time I visited the slough at night (August 20) the ducks were not visible but sounds of splashing were loud and constant, indicating that many were feeding. In daytime the ducks mostly drifted on the surface or stood on the mud beaches. There was some intermingling of the three species but mostly the greater numbers of each remained in separate flocks. This was readily apparent when too close an approach on my part caused the ducks to rise. Invariably the mallards, or some of them, were the first to rise, the baldpates next, the pintails last. Sometimes the mallards rose in detachments of several hundred, the last flock lifting perhaps five minutes after the first had disappeared over the top of the surrounding aspen woods. It was thought probable that those first to leave were the more wary and nervous adult males, now strong in flight although still in eclipse.

Anas acuta Linnaeus, Pintail.—Present in small numbers during the latter part of the spring migration May 1 to 8; prior to this pintail were reported to be more plentiful. The largest number seen together was 15, May 1, on a small pond north of the Nechaco River. During the ensuing three weeks of May and through June single birds, a male and female together, or small groups up to six of both sexes, were recorded with some regularity; during July smaller numbers were seen, and less frequently.

Although pintails were present all summer, and several pairs were recorded early in the season, nesting was not definitely established. The behavior of a pair on Bradley's Slough indicated breeding, as on May 22 when it performed the courtship-flight — the male flying sometimes above, sometimes behind, the female. Later a pair, presumably the same, was seen there frequently; the male, when alone, acted in the manner characteristic of a mated pintail, and continued to do so until June 22. On July 6 a female that alighted on the slough made short flights across the water, quacked excitedly and acted generally as the female of this species does when she has young concealed under cover.

The first male in eclipse plumage to be recorded was in company with four baldpates at Tachick Lake on July 4; on July 8 an eclipse male, and

a female, stood together on the beach at the west end of Sinkut Lake; on August 20 the first autumn flight arrived, at Middle Bay. This consisted of 60±, nearly all eclipse males, in association with a smaller number of mallard and baldpate. A flock composed of these species, changing in its elements from day to day, frequented the shallows during the remainder of my stay. The ducks fed, by dipping, in the shallows close to the shore-margin of willows; the long, slim triangles above the water, made by the "tipped-up" pintails, afforded a reliable method of identification at a distance. Several times, after the ducks had been flushed, it was seen that numerous shed feathers floated on the water; many of these were from pintails. On August 22 approximately 250 pintail, the majority eclipse males, visited Bradley's Slough. None was seen subsequently until August 28 when 150, not identified as to age and sex, were counted on the Nechaco River near Vanderhoof. An adult male, found in a dying condition at Middle Bay, Nulki Lake, on August 26, was in full eclipse. On August 31 at Bradley's Slough, the first flight of females and young comprising approximately 100 individuals, was recorded.

In 1946 the first evidence of a southern migration was noted August 8 when a flock of 24 appeared on Bradley's Slough. From that date until I left the district on August 29 pintails were seen on this slough each of the times it was visited, the largest number recorded being 1100± on August 28.

Anas carolinensis Gmelin, Green-winged Teal.—Green-winged teal were present on all the larger marsh areas during the period of my stay. A flock of 17, another of 10, were counted on May 5, and throughout that month pairs and trios (two males, one female) were seen in courtship flight. In the latter part of May and the first week of June it was common to see mated birds together. At that time single males were conspicuous on their territories and sometimes several males rested on some mud bar or stranded log. The latest date on which a mated pair was seen together is July 1; prior to that date the first indication of a post-nesting association of males had been noted, viz.: June 16. All had disappeared from the open ponds by the first week of July; whether they moved out of the district or merely retreated into the larger marshes was not learned.

In the dry sedge marsh at Manson's Slough, June 17, a nest of fine grass, mixed with down, and feathers from the duck's belly, contained two fresh eggs (buried in the down) and the shells of four other eggs that had been eaten by crows. This was the only nest found.

The average number of young in four broods, observed on open water, was 6.2. Other broods concealed in marsh growth, their presence indicated by the actions of the females, could not be counted — no small downy young were seen; all those recorded were in the adolescent stage. Many young were flying by the last 10 days of August; on August 31 flocks totalling 60, on Bradley's Slough, were composed chiefly of young.

No broods were seen in 1946. The first indication noted of a southern migration was at Sinkut Lake, August 25, when a flock of 25 was observed

in flight. A flock of equal number, perhaps the same one, visited Bradley's Slough the following day, and on August 28 thirty were counted there.

Anas discors Linnaeus, Blue-winged Teal.—None was seen until May 19 when six appeared on Bradley's Slough. Afterwards the species became common and remained so during the summer. The Lakes District represents the most northerly nesting ground in British Columbia, so far reported, west of the Rocky Mountains.

These tame and gentle ducks were under observation almost daily. Populations nested at Bradley's Slough, Manson's Slough, Nulki Lake, Tachik Lake and elsewhere. In early summer pairs visited some of the small forest ponds and meadow sloughs where food was abundant.

Courtship Behavior.—The majority was paired when the population arrived — at least their actions suggested this to be so. Thus the six birds which arrived on Bradley's Slough, May 19, drifted about within a restricted area close to the marshy shore. At times all swam close together, the males bowing continually, the females only occasionally. Again the flock would separate into pairs or trios; no evidence of hostility between one male and another was observed at this time; indeed, such instances were rare during the entire courting period. Now and again a short flight, seldom farther than 30 yards, was made by one pair or another, but always the six birds drifted together again. Examples of this close community amongst mated pairs was observed at other places many times.

Amongst the populations on Nulki Lake was one consisting of two pairs that frequented Middle Bay and the shore of the peninsula forming its northern boundary. Here they were observed, sometimes from a concealed position, many times. Thus on June 1 the two pairs came within a few feet of my hiding place, and for 15-20 minutes their courtship behavior was under close scrutiny. The ducks weaved in and out amongst flooded alders and swam alongside a small patch of cattails. Suddenly all would rise and pass out of my view, then, accompanied by a rapid explosion of wing-beats, as suddenly reappear on the water below me. For a time one female swam in company with two males, the female bowing, the males not. At this time the principal item of courtship-behavior was a sudden flight by the female and close pursuit by the male. In flight the female was silent; the male made a scarcely perceptible vocal sound. Upon alighting the male uttered a high-pitched, strident double call, difficult to describe. It was definitely nasal, somewhat coot-like in quality and repeated two or three times. A repetition of the sound suggested by *ah* against the roof of the mouth and on a high note, the second longer and more pronounced than the first, *ah-aah* gives a fair imitation of the sound.

The same day, 1:30 to 2:00 p.m., two pairs and one male on Bradley's Slough acted in the following manner: in company, but usually with a space of several yards between the pairs, the birds drift, or paddle along the edge of the sedge marsh. Occasionally one male rushes at another male; the second male turns towards the on-coming male and advances, but the two do not come together. The attacking male retreats to a position beside his mate; she utters

a tenuous quacking for five minutes, then the second female does so for a shorter period. One of the males commences bowing, the neck stretched and carried forward; sometimes the tip of the bill is thrust into the water and in this position he swims slowly towards the female. The other male then behaves in a like manner. The un-mated male swims to one pair, then to another, and bows repeatedly. These actions are interrupted by periods in which all drift and preen themselves vigorously. Occasionally one stands upright and stretches its wings. The two pairs drift apart, then come together again; the unattached male leaves them and swims toward the opposite side of the lake. A third pair alights 100 yards or so from shore; the male, then the female, commence bowing. The female swims in front of the male passing almost under the arch made by his curved and out-thrust neck — or so it seems from a distance. This pair swims towards the other two pairs, which are idling close inshore, and together the intermittent bowing, the preening and loafing, are continued.

These small populations regularly frequented a communal territory and later, during the incubation period, males awaited the females there. Thus at Bradley's Slough on June 8, 8:00 a.m. to 11:00 a.m., and again on June 11, 8:00 a.m. to 12:00 noon, eight males were on the same portion of the slough. They loafed alongshore or drifted on the water; none bowed nor was any feeding done during these periods. The following day 7:00 p.m. to 8:00 p.m. each of five males was accompanied by a female. On June 14 the males were alone from 8:00 a.m. to 11:30 a.m., then a female alighted beside one of them. She immediately commenced to wash, splashing and thrashing her head and neck into the water with a vigorous movement which submerged the forward part of her body to the shoulders. After doing so several times in quick succession she rose upright, shook her wings, then dropped to an horizontal position and, after shaking her tail several times, resumed splashing. When five minutes had been spent alternately washing and shaking the water from her wings she commenced a thorough dressing of her plumage. She ran her bill over her tail, under the scapulars, under the lifted wing and through the flank feathers; several times she scratched head and neck with her foot. Meanwhile the male, floating beside her, also engaged in these activities but with noticeably less vigor. Ten minutes after the female had alighted beside the male the pair moved off slowly, the female making sudden dabs at the water with her bill as though picking up insects from the surface.

During early summer the number of blue-winged teal on Bradley's Slough varied, and it was concluded that from time to time pairs nesting elsewhere visited this place and associated temporarily with the nesting population. Thus on the afternoon of June 7 a total of 17 was on the usual loafing-ground — a small area of 2 to 3 acres at one end of the slough.

Males were seen bowing and in display flights as late as June 18, and at Bradley's Slough on this date one male was seen rushing another male several times. One of these males was joined by a female at 2:45 p.m. By June 23 it was observed that some males had left the communal territory and within a day or so the majority disappeared. None was seen on terri-

tories after June 27 and this also was the latest date on which a pair was seen together.

Nesting.—The Manson Slough population, estimated to comprise 14 pairs, nested on dry ground, sloping upward from the marsh edge. This territory was covered with sedges along its inner circumference, and with various grasses, dandelions, mint and other plants farther up the slope. The outer circumference consisted of hay land, part of it in crop to alsike clover, another portion sown to oats. No attempt was made to locate nests until June 16 when, it was assumed, all or most of the females would be incubating and hence less likely to desert if disturbed. It was found, however, on the first day's search for nests (June 16) that early-laid clutches had been destroyed by crows, and some nests, evidently second attempts, did not contain full complements of eggs. Most of the blue-winged teal which came under observation that day were in pairs. Crow-predation was not anticipated because no crows had been seen during the numerous times the marsh was visited in May and early June.

A total of 12 nests was examined at Manson's Slough between June 16 and July 1. A few were close to, the majority 50 to 500 feet from, the water. A typical nest is illustrated by Fig. 20. In six the eggs had been eaten by crows prior to the time the nests were found; the nest was pulled out from its foundation, the egg-shells scattered on the ground close to it. All the nests were deeply cup-shaped and averaged four inches in diameter at the top. All were made of small, dry fragments of sedge or grass, and varying quantities of down depending on the length of occupation; as incubation progressed more down was added until the accumulation formed a rim two inches or more above the eggs.

A nest from which the female flushed was quickly found, but in subsequent visits to it careful search sometimes was necessary, if the female were absent, even though markers had been placed nearby. Down completely covered the eggs, and the surrounding litter encroached upon the down so that only a small portion of it, easily overlooked, was visible amongst the thick vegetation. When flushed from the nest the duck invariably discharged semi-liquid excrement over the eggs.

Few males were recorded after the nesting season; whether the majority retreated into thick marsh cover, or whether it left the district, was not determined. One was flushed from a marsh on the north side of Nulki Lake on July 1, another from Stony Creek on July 3. On August 6 three males in full eclipse were flushed from marshes at Tachick Lake, and on August 13 two eclipse males were seen in flight at Nulki Lake. None was recorded subsequently.

SIX NESTS AT MANSON'S SLOUGH

1. Five feet from water's edge in base of sedge clump and hidden by the tall stems. This was discovered through seeing a female swim out from the shore and join a male that had been under observation for some minutes as he loafed on the water 40 yards from the nest, it was estimated later. Nest contained 10 eggs and a large quantity of down on June 16. When visited again on June 18, 2:00 p. m., the female was flushed; on June 27, 3:30 p. m. the female was absent, the eggs covered. Hatching was successful.

2. Well concealed in short grass and dandelion; rim of down 1½ to 2 inches above ground. Female flushed from nine eggs on June 17, and again on June 27 at 3:30 p. m., when she flew approximately 100 yards and alighted in a field of oats. On July 1 at 11:00 a. m. the female was absent, the eggs covered. Subsequent history not known.

3. Similar situation. Nest contained nine eggs on June 17 and 10 eggs on June 27. The female was flushed on June 17 but was absent on June 27 at 3:05 p. m. and on July 1 at 11:00 a. m. Hatching successful.

4. Similar situation. 10 eggs. Female was flushed on June 17; she was absent, and the eggs were covered, on June 27 at 3:08 p. m.; she was flushed on July 1 at 11:20 a. m. Hatching successful.

5. Similar situation. Female was flushed from 11 eggs on June 1; subsequent history not known.

6. At edge of sedge marsh, 10 feet from a nest that earlier had been raided by crows. A female was flushed from this nest on July 1, when it contained 9 eggs, and again on July 14 when it contained 10 eggs. The duck was still incubating on July 21. Hatching successful.

Only one nest was located at Bradley's Slough. This was in a sedge clump 50 feet from the water's edge. When discovered on June 11 each of seven egg shells, in and about the nest, had a ragged hole in the side signifying the contents had been eaten by crows.

Broods.—The first downy young were observed, at Bradley's Slough, on July 2. The average number of young in nine broods was 7.7. This number by no means represents the total successful hatching of blue-winged teal in the Lakes District. The young usually keep under cover, consequently opportunities to observe them in the open are relatively few. One brood of 13 was seen, July 13, in an oat-field, where the plants were rather sparse and only a foot high or less. All the other broods were counted on open ponds.

Females with broods on open water, when approached in a canoe, defended their young by rushing over the water and making short flights while the young retreated into marsh cover. On July 15, at Bradley's Slough, a female with eight young about two weeks old was observed swimming close to, and parallel with, a female buffle-head accompanied by 18 young. The female teal flew towards my canoe, alighted nearby and surged over the water in the characteristic manner. She accompanied my course, and repeated this performance several times, while I paddled a distance of about 200 yards. Meanwhile the young teal had joined the buffle-heads and the combined broods, led by the female buffle-head, scampered over the water. Later one other instance of young blue-winged teal accompanying young buffle-head was observed.

Several instances of broods of small young not accompanied by a mother, and other instances of single young lost from a brood, were noted on Bradley's Slough. Four small, dead young were found there; none showed evidence of an injury that could have been fatal. Presumably these were weak birds lost from the brood and unable to care for themselves.

In 1946 two males and one female were observed on Bradley's Slough, June 10 and June 22. These were the only records.

Mareca americana (Gmelin), Baldpate.—The most plentiful nesting pond duck in the Lakes District. During the first three weeks of May flocks up to

30 associated with flocks of diving ducks feeding in deep water, with coots, and, on one occasion (May 1) with a flock of whistling swans. Others were observed "dipping" in the shallows, as at Nulki Lake, May 4, when I watched a flock of 10 that sometimes came within 20 feet and less of my place of concealment. Later these 10 joined other baldpates that accompanied a flock of about 130 coots on deeper water.

The first mated pair were observed May 22; on this date, subsequently for several days, small groups frequently were seen in courtship-flight over Manson's Slough; sometimes three or four males and one or two females together circled the marsh several times; sometimes a pair in flight was joined by a second male. The number of males apparently exceeded the number of females and it was not uncommon during the courtship-period to find a single female in company with as many as three or four males. Courtship-flight was last recorded on June 1; in this instance two males and one female participated. During a number of successive days mated pairs occupied certain restricted areas of water close to the brush-lined shore of Middle Bay, Nulki Lake, the edge of a nearby marsh, and the open ponds in Manson's Slough. Usually the two ducks swam or drifted close together, the female generally relaxed, the male sometimes alert with neck stretched upward and slightly curved. No sounds were heard, nor any active courtship observed, under these circumstances. Later, pairs were seen together only in early morning; at other times males were alone on their territories. The last observation of a mated pair together was made on June 21. Small groups on these waters, consisting usually of two or three males and one female, did not fit into this general pattern of behavior; it might be concluded that such represented a portion of the population which, for one reason or another, had failed in securing mates, or had nested unsuccessfully.

A nest at Manson's Slough, June 17, situated amongst tall sedges, was made of desiccated sedge and contained no down; the eight eggs had been destroyed by crows.

At Sinkut Creek, June 13, 1946, a female was flushed from a nest situated about 10 feet from the water's edge on a willow-covered bank. The nest, containing eight eggs, was hidden amongst a thick vegetation of grasses, cow-parsnips, fireweed, horsetail and mertensia. It was determined later that this nesting was successful.

In 1945 the earliest date for downy young is July 4; the average number in 37 broods was seven; in 1946 the earliest date for young is July 3; the average number of young in eight broods was 6.6.

It was observed with interest that females accompanied by young when alarmed rarely acted in the manner that seems characteristic of their behavior elsewhere, viz.: flapping over the water towards the observer, making short flights, and accompanying or preceding the moving canoe, while the young retreat into cover. This series of actions was observed rarely. The common behavior was for the female to swim slowly ahead of the brood and, if pressed, to lead them in a rush across the water to safety. At Nulki Lake family groups frequently were seen swimming close to shore under overhanging brush; these walked on to shore when approached — as do mallards under

the same circumstances. In 1946 late broods still were accompanied by females in mid-August. Thus at Tachick Lake, August 9, several females led, and defended, broods of large young, as did a female on Nulki Lake, August 16.

The association of several females and their broods was a common occurrence. Thus at Nulki Lake, July 24, one band was composed of five females and 38 young, another of two females and 16 young. On July 19 at Tachick Lake one female was accompanied by 19 young.

A post-nesting concentration in which males predominated was first observed on June 16 at Manson's Slough when one flock of 50 and another of 25 flushed from the ponds. At this date, as has been pointed out, pairs still were together on their territories. The concentration mentioned, and others observed elsewhere, are referred to as 'post-breeding,' but in all probability each contained a percentage of birds which had not nested. On June 17, when a flock of 40 was flushed, the ducks flew in wide, erratic sweeps over the marsh, sometimes breaking into smaller units, then coming together again and continually gaining altitude. Finally one group of 30 flew straight away in the direction of Nulki Lake; the remainder dropped down to the marsh and alighted. The baldpates present the following day acted in an identical manner. This particular slough was occupied by flocked baldpates until June 27 at least. On that date the flock consisted of 27 males and three females.

Other such concentrations were recorded as follows, viz.: Bradley's Slough, June 23, 22 males and four females; Tachick Lake, July 4, approximately 80, chiefly males, in association with a raft of redhead and lesser scaup duck; Middle Bay, Nulki Lake, July 15, 100±, in company with mallard, lesser scaup ducks and golden-eyes; west end Nulki Lake, July 24, 300±; none in flightless condition was observed; a flock of 30, chiefly males, on Tachick Lake, August 6, had apparently renewed the flight feathers.

In late August, 1945, flocks of baldpate commenced to gather on Bradley's Slough and on Nulki Lake. At the first place, on August 22, a flock of 200±, contained a large proportion of adult males in full eclipse, the remainder being females and flying young. On August 31 this flock numbered approximately 400. In 1946 a post-breeding population again gathered on Bradley's Slough.

Spatula clypeata (Linnaeus), Shoveller.—On May 2 ten males were observed on Manson's Slough and 15 on Nulki Lake; no females were identified with certainty. On May 4 a total of 200±, and 50±, about equally divided as to sex, were counted on Manson's Slough and Bradley's Slough respectively. On that day I made a complete circuit of Manson's Slough; the shovellers, scattered over the flooded marsh, rose and alighted again several times, then, in small flocks, flew in the direction of Nulki Lake. The same number, approximately, was present on May 6 but by May 8 the total was reduced to 50±.

Apparently the period May 4 to 8 witnessed the peak of the migration. A relatively small number remained and were conspicuous on Manson's

Slough and elsewhere for some weeks following. At Manson's Slough males frequently were observed as they glided along the open channels through the sedges, or as they took wing to perform swift courtship-flights over the marsh. On May 22 one such flight by four males and two females was accompanied by a male pintail. Similar courtship flights were watched numerous times at Bradley's Slough, where at this time pairs occupied definite, restricted areas along the shore (more easily identified than in the heavy marsh at Manson's Slough). Pairs were seen daily on these territories. Except for frequent display flights around the slough, performed either by a trio, by several of both sexes, or by males alone, the only item of courtship-behavior noted was a desultory bowing by the male. Once the female of a pair quacked continuously for nearly five minutes; the male bowed at short intervals. Courtship-flights were a common sight until May 29, and as late as June 7 pairs were seen together on Manson's Slough. But during the early part of June, the populations on Manson's Slough and Bradley's Slough, that had courted and presumably nested there, disappeared. It was concluded that first attempts at nesting had not succeeded and that few, if any, second attempts had been made. Possibly crow-predation was a factor in the unsuccessful nesting. The four eggs in the only nest found, at Manson's Slough on June 16, had been eaten by crows. On July 3 a female came out of a small marsh on Stony Creek, alighted beside my canoe, and acted as though she had young concealed. A female with brood of five young about three-quarters grown was seen on Nulki Lake, July 24. These two records constitute the only evidence of successful nesting in 1945.

In the latter part of May small flocks of males seen in flight or resting on open beaches and on open water, were regarded as post-breeding birds on the move. So also was a single male at Bradley's Slough, June 12. For a time this duck loafed with a male blue-winged teal, then swam along shore, about 20 yards out, and fed intermittently submerging head and neck to the shoulders. It did not tip up.

On August 9, 1946, flocks totalling an estimated 70, the majority adult males in eclipse, were loafing in the shallows at the west end of Tachick Lake. When approached they rose in small flocks, the largest numbering 14, and flew eastward. At the east end of this lake, August 21, three full-grown young followed an adult male redhead, and at Middle Bay, Nulki Lake, August 26, a flock of 14 young accompanied a larger number of baldpate.

Aythya americana (Eyton), Redhead.—In early May a transient population occupied Bradley's Slough where it associated with other diving ducks, baldpates and shovellers, on open water. The largest number present, viz.: 27 males, 18 females, was counted on May 5. The number was reduced to 15 (10 males, 5 females) on May 8, to two pair on May 22 and to one pair by June 8. The actions of the pair were those of mated birds, viz.: continual courtship; the male frequently alone on open water obviously awaiting arrival of the female; the female in flight, perhaps from the nest, joining the male on the water. However in late June both ducks left the slough probably after an unsuccessful attempt at nesting, the male being last seen on June 23, the female on June 25.

At least four pairs frequented the open ponds on Manson's Slough where often all were seen together idling on the water. A male sometimes rushed across the water towards a female and part, or all, of the flock frequently flew in courtship-flight low over the marsh. One pair was seen together as late as June 16, and on July 14 a female that flushed from the marsh was thought to have her brood concealed there.

Courtship-behavior, as witnessed on Bradley's Slough, May 22, was as follows: both ducks swam about slowly, the female leading. Sometimes the distance between them was a foot or so, sometimes only a few inches. Once the male attempted to seize the female by the feathers on the hind neck, several times he grasped her tail. Frequently in a slow, graceful movement he threw head and neck backward into a pisition parallel with, and almost touching, his back. Finally the two ducks drifted apart. Again, on June 8, 8:00 a.m. to 10:30 a.m., the male behaved somewhat differently. He followed the female at a distance of several feet, jerking his bill upward, to a vertical position, a dozen or more times in slow succession — a movement less graceful than the one previously described.

On June 4 a nest containing seven eggs was found in Collins' Marsh. It was made of dry cattail and measured 14 inches in diameter, the upper surface being eight inches above the water. The site was a small cattail clump which afforded little concealment. The nest held little down and none appeared to have been added; neither had additional eggs been laid when it was next visited on July 1. On both occasions the female was flushed from the nest and later, from a distance, seen alighting beside it. Hatching was successful.

Redheads nested also on Stony Creek, at the west end of Nulki Lake and at the west end of Tachick Lake. The following broods were observed, viz.: Stony Creek, July 3, female and six downy young; Tachick Lake, July 4, four downy young not accompanied by the parent; Nulki Lake, July 24, female and seven downy young; Tachick Lake, August 6, female and two young about 10 days old. These constitute the most northerly records of the redhead nesting in British Columbia.

During late May a small flock, usually consisting of four males and two females, regularly visited Middle Bay, Nulki Lake, to feed. They were thought to be part of the population at Manson's Slough a mile distant. On Stony Creek, July 3, seven females, perhaps non-breeding birds, were seen on the water in company with 20 yearling Barrow golden-eye. A post-nesting concentration was first observed July 4, at Tachick Lake, when 40±, chiefly males, associated on open water in company with lesser scaup ducks and baldpates. At Nulki Lake, July 15, 20 formed part of a rafted association of ducks on Middle Bay.

Aythya collaris (Donovan), Ring-necked Ducks.—On May 4 and 5 approximately 40 males and 10 females formed part of a large association of ducks that occupied Bradley's Slough. On May 8 a count of 14 was made and thereafter, until June 11, this number, in pairs, was observed there frequently. Later the population was reduced by one pair. Apparently six

pairs nested nearby and used the slough as a courting, resting and feeding place. From May 22 until June 18 the six pairs almost invariably were in company at the numerous times during daylight hours the slough was visited. Sometimes they were observed feeding; one, then another would dive until all were beneath the surface. They were seen occasionally in display-flight, more often drifting on the quiet water and dressing their plumage. On windy days they kept close to the lee shore.

On May 24 a female, flying from the distant end of an adjoining meadow, alighted on the water and immediately a male joined her. The female quacked softly for several minutes without a pause. The only item of courtship-behavior observed was on June 11 when several times a male attempted to grasp the dorsal feathers of a female with his bill.

On June 22, 6:30 p.m., the six males and one female were together; on June 25, 2:30 p.m., the six males were observed in flight and none of the females was on the lake. The last record for males of this population was June 27 at 8:00 a.m., when four accompanied one female.

So far as could be determined only two broods, both newly hatched, were brought to the slough — one of eight on July 4 and one of six on July 16. Both families left the slough, presumably for Nulki Lake, within a day or so.

At Tachick Lake on July 8 a female and brood of nine about 10 days old were observed at close range: on July 12 a nest, in which 10 eggs had recently hatched, was examined. It was composed of dry sedge to which a small amount of down had been added, the site being at the lake edge of a narrow sedge marsh. Identification was based on the color of the eggs and the character of the down.

The only post-nesting concentration of males recorded was on Tachick Lake, July 14, where 10 were seen swimming in a dense patch of yellow pond lily.

In 1946 the species was less common, the only records being one pair on Bradley's Slough, June 14; two large downy young, and one young about three-quarters grown, swimming amongst tangled masses of *Potamogeton Friesii* at Tachick Lake on August 9.

Aythya valisineria (Wilson), Canvas-back.—A migration of canvas-back had probably passed its peak before I arrived in the district, the largest number counted being 50± on the Nechaco River, near Vanderhoof, on May 1, and 100± on Middle Bay, Nulki Lake, on May 2. In these flocks the ratio of males to females was approximately three to one. At Bradley's Slough two males were recorded on May 5 and one male and one female on May 8. The same day four males and two females were seen on Manson's Slough. The species was not recorded again until May 27 when two males appeared on Middle Bay. The following day these, or another two, were accompanied by one female. None was seen subsequently until August 27. On that date at Middle Bay I came suddenly upon an adult male standing on the beach. It swam out on the lake and dived. The appearance and behavior of this duck indicated it to be in the process of renewing the flight feathers.

Aythya marila (Linnaeus), Greater Scaup Duck.—Scaup ducks of both species congregated on the Nechaco River, on Middle Bay, Nulki Lake, and on Tachick Lake during the first two weeks of May. Some, studied at 75 to 100 yards through binoculars, were identified satisfactorily as *marila*, others at nearer range, as *affinis*. But under the limitations imposed by usually distant observation, and inadequate binoculars, specific determination seldom was possible. Totals, of both species, on Middle Bay were estimated as follows: May 6 to 7, 450 to 500; May 8, 60; May 9 to 11, 200; May 12, 100; May 13, 200; after the last date no greater scaup ducks were identified. The total of both scaup ducks on Tachick Lake, May 7, was estimated to be 600.

Aythya affinis (Wilson), Lesser Scaup Duck.—The majority of the scaup ducks that frequented Middle Bay during the first half of May (see Greater Scaup Duck) spent most of the daylight hours one-half mile and more from shore. In the evenings they swam inshore, the majority not coming closer than 300 yards. However, several times small numbers came within a few yards of the beach and, invariably, those were lesser scaup ducks. All the scaups studied at this time on Bradley's Slough were identified as this species. By May 17 the scaup migration appeared to be over and many of the remaining birds (all lesser scaup duck) associated in pairs, some pairs by themselves, others amongst flocks that otherwise probably consisted of yearling males and females. Thus on Bradley's Slough a flock of 30, present from May 4, or earlier, until May 19, was so composed. On the last date, or shortly after, the yearlings moved elsewhere; the residual population, first three pairs, then two pairs (after May 24), were seen on the slough almost daily until June 27. They did not fraternize, as ring-necked ducks commonly do. Several times, on June 11, the male of one pair was seen advancing, with bill wide-open, towards his mate and, having come close to her from behind, attempting to take hold of the feathers on her back. Possibly the nesting of these birds proved unsuccessful; at any rate no broods were brought to the slough and the last recorded occurrence there was for one pair on July 2.

On May 17 three pairs on Middle Bay were observed in copulation, the female sunk low in the water with no part of her body visible from where I stood. Pairs, sometimes as many as six, were observed here daily until May 30. No broods appeared on Middle Bay but it was the scene of a post-nesting association, as will be noted later.

Mated pairs were recorded also on Manson's Slough, on Stony Creek and on Tachick Lake. The last probably supported the largest local population; 15 pairs were counted there on open water adjacent to the marshes at the west end of the lake, July 8, July 12.

The first downy young were observed on July 24, at the west end of Nulki Lake, the broods numbering 4, 6, 12, 16. Each was led by a single female. At the west end of Tachick Lake, August 6, a female with brood of six about one week old, a female with brood of 10 about two weeks old, and a band of 19 young of different ages and not accompanied by parents, were recorded.

On July 4, July 8, a flock of 100±, composed chiefly of non-breeding yearlings, came under observation at Tachick Lake. These were accompanied by baldpates, redhead and Barrow golden-eye. On July 15 approximately 50 lesser scaup ducks formed part of an association of diving ducks congregated on Middle Bay. This number, thought to include both non-breeding yearlings of both sexes and post-breeding, adult males, increased as the days passed until, on July 24, it approximated 700. By August 5 the number was reduced to 300± and by August 16 all had disappeared.

A reduction in numbers was apparent in 1946. The only concentration of post-breeding males and non-breeding yearlings observed was at Tachick Lake, August 21, where some 100 birds were present on an area approximating one-half square mile.

Bucephala clangula (Linnaeus), American Golden-eye. — According to local report golden-eyes, probably of this species, wintered on the Nechaco River near Vanderhoof, 1944-45. Small flocks up to 10 were recorded, May 1 and 2, on this river, and on Nulki Lake and Bradley's Slough from May 6 to May 26. On the last date four males and two females accompanied other migrating ducks on Middle Bay.

A pair was seen together on Bradley's Slough almost daily, feeding, courting and resting, from May 16 until June 7 when the male left. The pair occupied a particular stretch of water, midway along the slough, more often than any other portion of the lake. The male was aggressive, more particularly so during the intervals of courtship, and attacked other ducks that swam into, or alighted on, this territory. Thus on May 22 he swam quickly towards a male buffle-head 30 yards or so distant, then dived, and, showing only bill and crown above the surface, rose beside the other. The buffle-head immediately retreated, 'dancing' over the water and thrashing his wings but never quite rising from the surface. It travelled thus in a wide circle. Each time it stopped 'dancing' and relaxed for a moment, the golden-eye dived and came up beside it. (This same behavior performed by two male Barrow golden-eye, one attacking, the other dancing a retreat, has been witnessed). All the actions of the mated golden-eye, observed at different times of day for several weeks, seemed to confirm the impression that they were nesting. Thus on the evening of May 29 the pair was together, the male drifting and dressing his plumage, the female feeding eagerly — behavior characteristic of mated golden-eyes during the laying period when the female leaves her nest and joins the male on the water. Frequently also the male was seen alone on the slough, as on June 1 between 1:30 p.m. and 3:30 p.m. It was last recorded on June 7.

On June 9, 7:00 p.m. to 8:00 p.m., the female came under close observation. She fed close to the shore following all its contours; the water was less than two feet in depth and upon submerging she remained under from 10 to 20 seconds. The yellow color on the end of her bill still was prominent. On June 22, 6:30 p.m., a female golden-eye, accompanied by seven downy young, was on the territory so often frequented by the pair. For several minutes, while she stood on a grass clump at the marsh edge 30 feet from

me, I examined her closely. It could be seen that the bill, now without any yellow marking, was of typical *americana* shape. Presumably this duck was the female of the pair that had been under observation for so long. On the same day a brood of Barrow golden-eye appeared on the slough, and later other broods of that species were brought there. The females and young of both species fraternized; as many as three broods were seen banded together, so that specific identification seldom was practicable.

Bucephala islandica (Gmelin), Barrow Golden-eye.—None was identified with certainty until May 5 when one, or more, adult males accompanied a flock of diving ducks on Middle Bay. About May 8 a pair arrived on Bradley's Slough and during the week following the species became fairly common in the Lakes District.

Only one pair frequented Bradley's Slough during the courtship period, although five broods were brought there in June and early July. The first brood, one of six, was recorded June 22. On June 24 a female with 10, another with 13 downy young appeared; on July 4 a female with 9, and on July 6 a female with 6 downy young were first seen. None of these families was raised to adolescence on this slough. The last brood was seen there on July 14; other broods were studied on Nulki Lake, Tachick Lake and Stony Creek. The average number of young in 22 broods was 9.5. In 1946 the first downy young were observed, at Bradley's Slough, June 14; the average number of young in 10 broods was 10. As in other localities the young of several broods sometimes banded together, for example, at Tachick Lake, July 24, a band of 22, all about one week old, was counted; this was not accompanied by an adult female.

The brood recorded for June 14, 1946, numbered 15; three days later it still was intact, and a second female had brought a brood of 18 to the water. On June 18 a third brood numbering 8 appeared. On June 26 there still remained 39 of the original 41 young. All had been taken from the slough, probably to Nulki Lake, by July 3.

The behavior of females with broods followed a familiar pattern. On Stony Creek, July 3, a female with 8 young, another with 11 young, swam upstream ahead of my canoe until about to be overtaken, then most of the brood scattered or dived; the female, in each instance, remained on the surface beside several of the young, which had not dived. When I returned an hour later both females had gathered their broods together. Females with broods on Tachick Lake, July 4, showed concern for their young by surging over the water close to my canoe while the young scampered over the surface, and each of the eight females which were approached closely temporarily deserted her brood.

The behavior of two females both thought to be *islandica*, one a yearling the other an adult with nine downy young, was unusual. The yearling alighted beside the adult and was immediately attacked with considerable vigor. A tussle followed, both ducks beating the water with their wings, and each grasping feathers of the other in its bill. Joined thus they tumbled about sometimes on the surface, sometimes submerged, for several minutes. The above observation was recorded at Bradley's Slough on July 4.

Adult males disappeared in the latter part of May; actually the last recorded observations for the Lakes District are May 19, 1945, and June 14, 1946. One seen at close range on Stuart River, June 28, the only golden-eye observed there, is a very late summer record for an adult male. The white crescent at the base of the bill was conspicuous and the violet head showed no trace of brown.

Yearling golden-eyes, chiefly females, were noted at many places. Thus on Bradley's Slough a flock varying from 4 to 7 was observed frequently between June 8 and June 24. Once, on June 9, four of these, two males and two females, acted in the same manner as courting adults, viz.: the males bowing and rushing across the water at one another or towards a female. This performance lasted for only 10 minutes, or less, and was not observed again. Usually the birds were busily feeding or else resting on one of several half-submerged logs. A flock of 4, another of 11, were counted on Stony Creek, July 3; on Tachick Lake, July 4, flocks of 3, 4, 5 and 3 single birds were recorded, and on Middle Bay, Nulki Lake, July 15, 40± formed part of a large association of diving ducks and baldpates.

On July 24, when a complete circuit of Nulki Lake was made by boat, it was found that a large part of the population, approximately 200, comprising adult females, yearling females and nearly full-grown young, was rafted with lesser scaup ducks. Additional birds counted were: one band of 40 young one-third to two-thirds grown, two young about one-half grown and one solitary young of similar size, and the following broods, viz.: 10, 10, 6, 5, all the last well-grown and each brood led by a female.

On August 17 a full-grown young male, apparently representing this species, was caught in a fisherman's net and presented to me. This specimen has the wide bill and small nail usually regarded as diagnostic of *americana* and the characteristic non-bulbous trachea of *islandica*.

Bucephala albeola (Linnaeus), Buffle-head.—In early May adult male buffle-head were conspicuous amongst flocks of this species that associated with other ducks on Nulki Lake, Tachick Lake and the larger sloughs; courtship continually was in progress. By May 19 the numbers had decreased, the residual population being sorted into pairs, and groups of non-breeding yearlings in which females predominated. Thus on Bradley's Slough, where 40 were counted on May 5. On May 24 the breeding population appeared to be established at seven pairs. Some observations of this community are set forth below.

The slough appeared to be communal territory for the seven pairs — no male defended any particular part of it against invasion by other males. Fighting amongst males, which was frequent, took place most often while several pairs were together in a flock, or when a group in which either sex might predominate, had come together. Most of the males were constantly on the slough during the laying period and at no time, so far as could be learned, were all the females absent. The following were typical groups that fed or courted together, viz.: May 29 — 4 males, 3 females; June 7 — 2 males, 2 females; June 10 — 2 males, 1 female; June 12 — 5 males, 6 females; June 14 — 3 males, 2 females; June 23 — 2 males, 4 females.

Vigorous courtship took place amongst the ducks in these groups. It was most intense in the early part of May and subsided gradually thereafter. On June 7 two males fought with each other and pursued the same female; one, in rapid flight, alighted beside the other and, carried forward by the momentum gained, struck the second male with some force. Later the identical action was directed towards a female Barrow golden-eye. Following this the two males, then two males and two females together, circled the lake in courtship-flight. On June 9, 7:00 p.m. to 8:00 p.m., four pairs drifted about on different parts of the slough; no aggressive action was observed. On June 12 a male, flying swiftly down the lake, swerved from its course to threaten another male on the water, then continued his flight. This was the last aggressive action to be noted. June 24 was the last date on which a pair was seen together and June 25 the last date on which an adult male was recorded.

Four broods, numbering respectively 6, 7, 8, 11 were brought to the slough on June 23; another of seven was recorded there on June 24. By June 27 six broods 5, 6, 6, 7, 8, 10, were present. Still another brood, numbering 13, appeared on July 5. Much fraternizing took place and it was inevitable that the original brood units could not be maintained. Thus, on July 6 each of seven females was accompanied by young in the following numbers: 1, 4, 4, 7, 10, 12, 14. During the following 12 days a portion of the population left the slough and on July 17 the remainder was divided thus: 1, 3, 7, 13, each of these groups being led by a female. On July 25 the total population consisted of one female with 15 young; by August 2 it was reduced to seven young about three-quarters grown. These were in company with a motherless brood of blue-winged teal.

On June 14, 1946, five adult males and five females together were very active, flying from one part of the slough to another between short intervals of feeding. There was no courtship display. Territory-defense was observed on the same date when a pair was together from 10:00 a.m. to 11:00 a.m. Twice the male rushed at, and put to flight, two yearling females that invaded the territory. The female was feeding during all of this hour; she dressed her plumage for a minute or less after each dive. The male drifted beside her, dressed the plumage on back, and on the undersides of the wings, and several times scratched his head with a foot. When the female left the slough he commenced to dive, remaining only a few seconds under water each time, then swam to another part of the slough. The last observation of a male was on June 17.

A female was flushed from a nest in a dead aspen standing amongst live aspens about 150 feet from the shore. The entrance to the nest was approximately 25 feet above ground.

The first downy young was recorded on June 17. This was a single bird, perhaps lost from a brood which had stopped for a short time on the slough before proceeding to Nulki Lake. It was still alone on June 22. On that date the first broods, 10 and 2, were observed there.

Broods were recorded also on Nulki Lake, on Tachick Lake, on Stony Creek and on a small lake in lodgepole pine woods. In 1945 the average

number of young in 33 broods was 6.7; in 1946 the average number of young in 12 broods was 5.7.

Yearling females, and a much smaller number of yearling males, were observed on all the lakes studied. One flock of seven constantly visited Bradley's Slough; on Tachick Lake, July 4, the following were counted: 2, 3, 3, 3, 4, 6, and four single birds. The largest group recorded numbered 20; these buffle-heads and a lesser number of golden-eyes often rested on a log boom on the north side of Nulki Lake.

Histrionicus histrionicus (Linnaeus), Harlequin Duck.—Reported from Stuart River, five miles south of Stuart Lake, in the summer of 1942, by C. D. Muirhead.

Melanitta fusca (Linnaeus), White-winged Scoter.—Seen twice on Nulki Lake, viz.: two on May 26 and five on July 24. The species may have nested at Tachick Lake. On July 4 three females and one male were flushed separately on different parts of the lake where the shore was covered with thick marsh growth. On the same day a flock of 10 was seen in flight. At 4:30 p.m., June 22, 1946, a flock of 14 males was seen flying in the direction of Nulki Lake; this was the only record for that year.

Melanitta perspicillata (Linnaeus). Surf Scoter.—Amongst the congregation of diving ducks on Middle Bay during May was a varying number of surf scoters; for example, 50 males, 10 females on May 2; 20 on May 6; 100± on May 21. The number on a small section of Tachick Lake, May 7, was estimated to be 50. The last of the spring transients recorded were five males and two females together on Middle Bay, May 26. On July 24 five were seen in flight, one behind another, at the west end of Nulki Lake.

Erismatura jamaicensis (Gmelin), Ruddy Duck.—During the spring migration small numbers of ruddy ducks, chiefly males, were recorded on Nulki Lake (May 2—15) and on Bradley's Slough (May 3, May 5—12). The population on Bradley's Slough during the remainder of May consisted of one pair plus two males. The two mated birds commonly were seen feeding along shore; they dived at short intervals and travelled the length of the slough in this manner. The two un-mated males occasionally accompanied them but more often were together on the center of the lake either by themselves or in company with other diving ducks. In June another female and two other males were seen there fairly regularly. Thus on June 20 three males and two females together on the center of the lake were under observation for one half-hour as they breasted a strong westerly wind. The largest number seen together there at any time was six, four males and two females, June 20. Courtship, noted on other nesting grounds as taking place continually until late summer, was never observed amongst this group, composed apparently of non-breeding birds, and once only (June 20) on the part of the mated pair. A nest of dry sedge-leaves and a small quantity of down, built near the water's edge in a sedge clump which provided adequate cover, contained 10 fresh eggs on June 23. The female was flushed from the nest on that day but not subsequently. After 10 days had passed it became obvious, from the condition of the eggs, that the nest was deserted. The pair

remained together on the slough; on one occasion the female was flushed from what seemed to be a possible nesting site in the sedges, on another she was observed feeding in the eager manner employed by a female which had left the nest for that purpose — dive following dive in quick succession. However, a second nesting, if attempted, was not successful; the male was last seen on July 2, the female on July 16.

A male ruddy duck was observed on Manson's Slough, May 22, May 27, and a male and female on Stony Creek, July 3. Small numbers on Tachick Lake, and at the west end of Nulki Lake, nested successfully. A brood of four downy young, and a brood of six large downy young, were counted on Tachick Lake, August 6; a brood of five large downy young on Nulki Lake was identified on August 13. Each of the three broods was led by a female. In 1946 four full-grown young were seen at the east end of Tachick Lake on August 21.

The most northerly nesting ground in British Columbia (west of the Rocky Mountains) previously reported is the southern Cariboo, some 150 miles to the southeast of Nulki Lake.

Lophodytes cucullatus (Linnaeus), Hooded Merganser.—A female and brood of five downy young were observed on Stuart River, June 28. One downy young was collected. On August 27 three flying young, and on August 30 two flying young, were flushed in Middle Bay. On August 27, 1946, a bird of the year was observed at Sinkut Lake, first as it rested on a small beach, later as it swam along shore in company with a young green-winged teal.

Mergus americanus Cassin, American Merganser.—A flock of seven, comprising four adult males, two yearling males and one female, was seen frequently in Middle Bay and South Bay, Nulki Lake, May 2-6. On one occasion, May 2, the birds stood on the ice close to open water; on another, May 6, they were watched from a concealed position as they fished along shore. One was seen emerging with a squawfish, about eight inches in length, crossways in its bill — the mandibles grasping the fish just behind the head. Immediately a second merganser rushed towards the one which had been successful but failed to arrive before the fish was swallowed. The movement of turning the fish head downward, and the first movement of ingestion, were so rapid as to almost escape detection. A flock of two adult males and four females, May 26, and a flock of three adult males and one female, June 10, are the only other records for Nulki Lake.

It was expected, from accounts received, that large merganser populations would be found on Stuart River and on Tachie River; but this was not so. On 16 miles of the Stuart River, June 28, a total of five females, or yearling males, or both was recorded, and on Tachie River, between Tachie and Grand Rapids, a distance of 14 miles approximately, only three were seen.

Nulki Lake is known to contain a large fish population of numerous species; Stuart River and Tachie River are reported to contain many sal-

monoids. The relative scarcity of mergansers on these waters is a matter of considerable interest.

Mergus serrator Linnaeus, Red-breasted Merganser.—An adult male and female observed through binoculars at a distance of approximately 50 yards, Tachick Lake, May 7, is the only record.

Accipiter gentilis (Linnaeus), Goshawk.—Adult male goshawks were seen at the following times and places, viz.: Stellako Valley, May 7; near Vanderhoof, May 12; Cluculz Lake, August 4. A young male shot near Nulki Lake on August 21 was brought to me to be identified. Another was recorded at Sinkut Creek, August 23, and a third at the outlet of Stony Creek on the Nechaco River, August 29. The last was seen making a clumsy and unsuccessful attempt to strike one of a flock of green-winged teal that stood on a log beside the stream.

In 1946 it was seen but once during the summer, and under the following circumstances: At Nulki Lake, July 4, an immature bald eagle soared, in wide circles, high above the ground but conspicuous against a white cloud-bank. From above a goshawk swooped, braking its swift descent before actually striking the eagle, then mounted and again descended. These attacks continued for the few minutes the two birds were in sight, before both disappeared behind the crest of a forested hill.

Accipiter striatus Vieillot, Sharp-shinned Hawk.—One adult was observed in flight at Nulki Lake, May 13, another on May 17. On May 30 in the Sinkut Meadows a male of the previous year was seen in close pursuit of a rough-winged swallow. A total of 10 individuals, chiefly young of the year, was recorded in different localities between July 31 and August 27. It was less common in 1946, only four being seen from June 11 to August 19.

Accipiter cooperi (Bonaparte), Cooper Hawk.—At Nulki Lake in the evening of May 22 an adult female Cooper hawk rose out of an aspen bluff and, flying only a few feet above the ground, passed me at about 30 feet. This is the only personal record. A male and a female were collected at Fort St. James on June 11, 1889 (Mair and MacFarlane 1908).

Buteo jamaicensis (Gmelin), Red-tailed Hawk.—On May 2, near Vanderhoof, a pair of red-tailed hawks was watched performing what may have been a courtship-flight. The female launched out from the top of a tall aspen and circled upward; from a considerable distance above the male plummeted down towards her; when only a short distance separated them the female turned partly on her back and extended her feet. The birds did not collide. Following this single episode both commenced to soar, rising higher and higher, never far apart, until they passed from view.

Single individuals, apparently on migration, were seen in the Lakes District on May 3, May 7, May 8. Two of these were dark, two were light-colored, below. During the autumn migration single adults were recorded on August 4, 15, 17, 20, 23, 26, 31, and a single young of the year on August 24.

On June 24 a local resident took me to see the deserted nest of a hawk built on a site that is unique in my experience, namely a witch's broom at the top of a slim, dead spruce, about 40 feet in height and 10 inches in circumference at the base. The tree was one of several standing in an old burn now grown up with small aspens. The nest, so far as could be seen from below, was made of sticks and weed stalks superimposed on the witch's broom (Fig. 21). The man who took me to the nest said that on May 28 the hawks were present and aggressive. He shook the tree and two eggs fell to the ground; one was broken, the other uninjured in the fall. Several days later I had an opportunity to examine the unbroken egg and identified it as that of a red-tailed hawk. A characteristic feather of this species found on the ground beside the nesting tree provided additional supporting evidence of identity. While I was examining the nest a pair of red-tailed hawks, possibly the pair that had occupied the nest a month earlier, soared over a wide valley about one-half mile away.

In 1946 red-tailed hawks were seen on only three occasions, viz.: an adult, July 4, a young bird on August 18, another on August 19.

Buteo harlani (Audubon), Harlan Hawk.—At Nulki Lake on August 25, 1945, I collected a young red-tailed hawk on migration. This specimen is extremely light-colored with a relatively small amount of black below; the back and all the wing-coverts are broadly tipped with white, not buff as in the ordinary run of young *Buteo j. calurus*; the upper tail surface is slightly mottled over its basal third. These characteristics are apparent in another specimen examined, an autumn transient of the same age taken at Falkland, British Columbia.

Specimens of this pale-colored redtail are known from Alaska, Yukon Territory, and from the Stikine River in northern British Columbia. Swarth (1922) remarks that "In a large series of young *calurus* from various parts of the western United States we have nothing at all like these birds." He goes on to say that he is disinclined to regard them as *krideri*, an opinion to which I subscribe. Rather, it seems to me, these pale northern birds represent a light phase of the species *Buteo harlani*, and, until a more satisfactory explanation is offered, this treatment would seem justified.

Buteo swainsoni Bonaparte, Swainson Hawk.—At Bradley's Slough, May 8, a chocolate-colored hawk of this species flew fairly low over my head, and on May 25 another, a dark, mottled specimen, alighted in an aspen beside the Nulki Lake-Vanderhoof Road. The last was observed at a distance of about 100 feet. These are the only records obtained.

Buteo lagopus (Brunnich), American Rough-legged Hawk.—About 20 miles south of Prince George on April 30 a good view was obtained of an adult rough-legged hawk standing in an aspen; later it was seen in flight. On August 19 an adult was seen flying over a burn on Sinkut Mountain. The dried-up carcass of one examined at Nulki Lake was a typical light-colored young of the year. It was learned that this bird had been shot the previous autumn.

Aquila chrysaëtos (Linnaeus), Golden Eagle.—Reported as a fairly regular, uncommon winter visitant.

Haliaeetus leucocephalus (Linnaeus), Bald Eagle.—At least four pairs nested in the Lakes District, one or more of these, or one or more of a population which included individuals identified as one-, two- and three-year olds, were seen almost daily. The largest numbers counted in one day were: two adults and three young on the ice at Sinkut Lake, May 2; eight adults and six young counted during a trip by boat around Nulki Lake on July 24. But, according to information submitted by several local residents, many more than these numbers may be seen on the lower reaches of Corkscrew Creek during the spawning run of Kamloops trout, and that of fine-scaled sucker which takes place later. On June 10, 1946, Mr. Roy Bradley counted 11 in flight between the outlet of Corkscrew Creek and the west end of Nulki Lake, a distance of one mile. It is reported that no eagles winter in the district; they arrive in late March and early April, often some considerable time before the ice goes out of the lakes.

A pair of bald eagles has nested on the Collins' farm at least since 1938, the year in which my informant, Mr. R. Collins, settled there. The first nest was in a dead aspen, standing high above second-growth aspens, about 50 yards from Mr. Collins' barn. The eagles became accustomed to the presence of people about them and carried on their various activities, that yearly included the raising of one or two young, with little regard for the close observation to which they often were subjected. This nest was used until the tree blew down in 1943. That year another nest was built in a live aspen growing close to the lake shore and about 300 yards from the Collins' house. The tree is approximately 14 inches in diameter at the base and about 45 feet in height; the large nest is situated two feet, more or less, from the top of the tree. Young were raised in this nest in 1943 and in 1944 but apparently not in 1945, although a pair was seen there frequently in April. One adult was perched beside the nest when I visited the site on June 3. Two young were raised in 1946.

Two of six Douglas firs, old, wind-contorted specimens prominent on the summit of an open ridge overlooking Sinkut Lake (Fig. 15), contain bald eagles' nests. One, said to be very old, measures approximately five feet in diameter. It is situated about 30 feet from the ground at a place where, years since, the main trunk broke off (Fig. 22). Above the nest a secondary leader extends upward for another 30 feet or so. The second nest is about 200 yards from the first, across a shallow, wooded draw. This nesting-tree, the largest of the six, is approximately 100 feet in height and three feet in diameter at the base; the nest, 50 feet or more above ground, is partly concealed by foliage. Neither of the nests contained young when the sites were visited on June 25; only one — that first described — has recently been occupied. As I approached the base of the ridge an adult flew out from this site and soared over the lake.

Another nest, used in 1945, is situated on the north shore of Sinkut Lake; still another, occupied, so it is said, since 1912 at least, is located on the lake's larger island. Neither of these sites was visited.

Bald eagles also were observed flying over Tachick Lake, where a pair is reported to nest; also at the east end of Francois Lake, at Stuart River and at Tachie River. At the last three localities two, three and four adults, respectively, were counted.

The nesting population in the Lakes District was thought to be the same in 1946, viz.: four pair. The date of the first arrival in spring, as noted by pupils at the Lakes District school, was March 8.

At Sinkut Creek, June 13, I came suddenly upon a second year bird standing on a gravel bar in mid-stream. Evidently this bird had been fishing for coarse-scaled suckers that were then spawning.

A group of aspens near the shore of South Bay, Nulki Lake, is a favorite perching place for bald eagles. On July 3 when an adult stood near the top of the tallest tree, partly concealed by the foliage, I walked directly underneath without causing it to take flight. Four black terns kept teasing it, swooping from above time and again. Not until I hammered on the tree did the eagle take flight.

Circus cyaneus Linnaeus, Marsh Hawk.—Two adult males, four adult females, and two females in the second year were recorded, all but one in the Lakes District, during spring and early summer. These include a pair that apparently nested close to headquarters at Nulki Lake. None was observed between Vanderhoof and Francois Lake on May 7, and one only between Vanderhoof and Stuart River on June 28.

The pair referred to above, during the period May 4-8, regularly hunted a wide, weed-covered summer-fallow. Sometimes the pair hunted together; more often only one of the pair was seen. Very often one or the other appeared about 12:00 noon, again about 6:00 p.m. They seemed to follow a regular beat that included the immediate surroundings of our cabin. From May 8 until May 24 only the male was seen; he appeared with the female on the evening of June 12 and was not seen again until July 2 when he appeared for the last time. From June 12 until June 29 the female was seen almost daily. She appeared less often afterwards and was last seen July 5. Twice in the spring one of the pair flushed a flock of pipits but seemed to pay no attention to them. The field contained a very large population of meadow voles; apparently it was this food that the hawks sought.

The latest record for an adult male is July 16, the latest for an adult female, August 4. Both were considered to be transients. The first young marsh hawk was recorded on July 9; none was seen again until August 9; after that date they became relatively common, as many as six being seen on one day, August 13.

In 1946 marsh hawks were less common; an adult female, apparently nesting in the Sinkut Meadows, was seen several times in June, and two young were recorded during August.

Pandion haliaëtus (Linnaeus), Osprey.—Ospreys nested near most of the lakes visited; many times during the summer one was seen fishing in Nulki Lake or flying inland towards its nest. The only nest site visited was situated

three air-line miles from, and about 600 feet above, Nulki Lake. The nest is at the top of a dead lodgepole pine, one of many still standing in an old burn on the north slope of Sinkut Mountain. A local resident told me this nest has been occupied each summer for at least 10 years. An adult was on the nest, only its head visible above the rim, on August 13; it was thought that the young had left several weeks earlier. On June 23, 1946, an adult and two young were in the nest.

At Bradley's Slough, May 6, a pair, flying low down and close together, circled slowly over the water. Occasionally one or other dropped to the surface, raking it with down-thrust feet. There are no fish in the slough and it soon became clear the birds were hunting nest material. Finally one of them grasped a large quantity of brownish vegetation, probably water moss, and, carrying the material in the same manner as a fish is carried, slanted up from the slough to follow a straight course which led over the hill top, probably to some distant nest. The second bird alighted on a fence post by the lake and after remaining there a few minutes flew to the far end of the slough, where it circled about beyond the range of accurate observation. It was observed that the numerous ducks on the lake paid no attention to the ospreys, even at times when the slow-flying hawks passed directly over, and only a few feet above, them.

Falco mexicanus Schlegel, Prairie Falcon.—A falcon that flew along the shore of Nulki Lake and alighted in a bare aspen near the beach, May 6, where it was observed at a distance of about 50 feet, was almost certainly of this species. No other large falcon was seen during the season.

Falco columbarius Linnaeus, Pigeon Hawk.—During the spring migration an adult male was recorded on May 1, another on May 3, a female on May 4, another on May 8. The only summer records are for a vagrant female seen once only, at Bradley's Slough, on June 27, and a male at Nulki Lake, July 12. Two were observed during the autumn migration, a young male August 25, and a young female, August 31.

Falco sparverius Linnaeus, Sparrow Hawk.—Not common either during the spring migration or in summer. Five were seen from May 2 to May 14, and three between May 15 and July 15. No evidence of nesting in the Lakes District was obtained. Somewhat more common in late summer, a total of eight being recorded between July 31 and August 4, and a total of 10 on August 10. On July 11 I saw an adult female rise from the roadside with a chipmunk in her claws. Burdened with the weight she flew slowly, close to the ground, and upon being pressed dropped it after flying 20 yards or less. The chipmunk was full-grown; one claw of the falcon had pierced its skull at the base of the brain case.

Dendragopus obscurus (Say), Blue Grouse.—Apparently blue grouse are completely absent from the Lakes District and I could find no evidence that the species ever occurred there. Mr. Phil Brown told me of seeing a few on Lookout Mountain on the north side of Stuart Lake. Probably this is the point nearest to Vanderhoof where the species is established.

Canachites franklini (Douglas), Franklin Grouse.—Scarce, observed only three times during the summer of 1945 as follows: one female north of the Nechaco River near Vanderhoof on May 9; one female, July 4, at a place on the Vanderhoof-Lakes District Road where it passes through lodgepole pine woods; a female, and brood of young about the size of song sparrows, by the roadside near Stuart River on June 28.

On the Sinkut Mountain trail, June 23, 1946, at a place where it traverses a lodgepole pine forest, a female Franklin grouse with brood of small young performed characteristic defense action. Crouched with wings trailing, all body feathers erect, and making soft cries, she crept ahead, sometimes allowing me to approach as close as four feet before she rose to fly a short distance along the road and there resume the defense-posture. This continued until I had covered a distance of about 100 yards, when she flew into the woods; one small young flew into a tree when first we came on the brood, the others were not seen.

On the same mountain, June 28, alongside the spruce and lodgepole pine edge of a sedge meadow, I flushed a female with seven or eight small young. This female walked about on the ground calling occasionally but made no other demonstration. The young, that had well-developed wings and flank feathers showing through the down, flew to low perches in the spruces.

A clutch of eggs was collected at Fort St. James, June 9, 1889 (Mair and MacFarlane 1908).

Bonasa umbellus (Linnaeus), Ruffed Grouse.—The ruffed grouse population of the Lakes District was estimated in May to be one to every 50 to 75 acres. During a motor trip on May 7, much of it through good grouse territory, viz.: west to Fraser Lake, south to Francois Lake and east to the Lakes District by the old Telegraph Road, a distance of approximately 180 miles, only 10 ruffed grouse were counted. Six was the largest number seen in one day (May 4) along the road from Nulki Lake to Vanderhoof, a distance of 10 miles, much of it through suitable ruffed grouse territory.

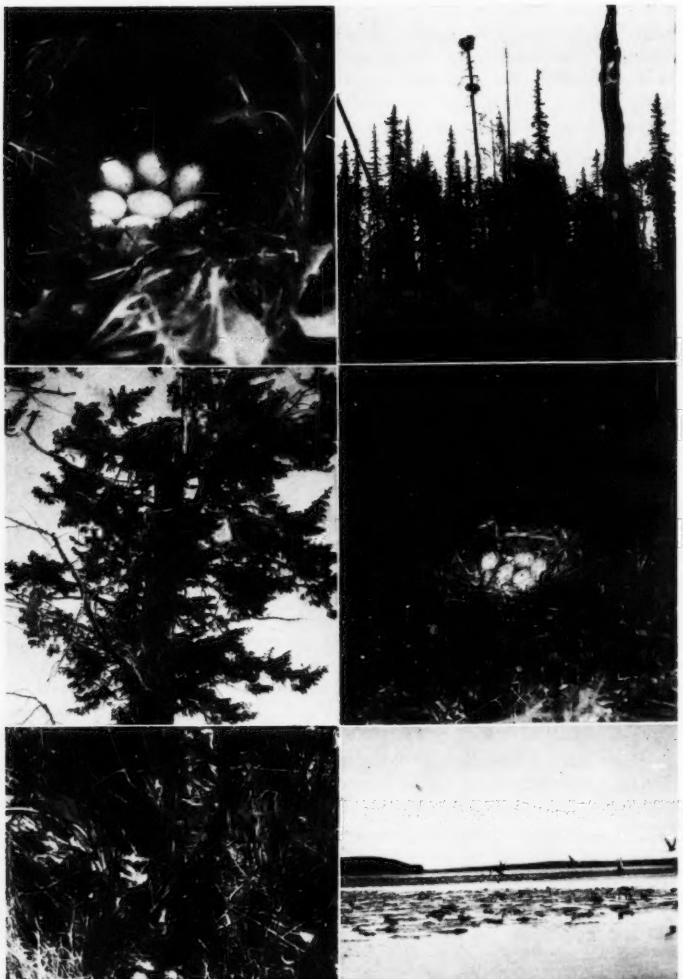
The first two broods, the number of young not counted, were observed June 21, June 23. Other broods noted were as follows: July 3, 1 brood, not counted; July 4, 1/9; July 8, 1/5; July 23, 1/2; August 28, 1/7.

The numerical status of the species in the Lakes District in 1945 was about what might be expected in the third year following the peak of abundance in 1942.

In June, 1946, a few were seen or heard drumming and it was suspected that the population was smaller than in 1945. However in late August when young were nearly full-grown the situation looked better. Actually more birds were counted than in the same period of 1945. For example, on August 26 nine were flushed separately from a pile of slash in a cleared field.

A clutch of eight eggs was collected at Fort St. James, May 16, 1889 (Mair and MacFarlane 1908).

Lagopus lagopus (Linnaeus), Willow Ptarmigan. — Reported from the Vanderhoof region, in winter only. Thus Mr. Phil Brown, in the winter of



Figs. 20-25. 20. Nest and eggs of blue-winged teal, Manson's Slough; 21. Nest of red-tailed hawk on top of witch's broom; 22. Nest of bald eagle at Sinkut Lake; 23. Nest and eggs of sora; 24. Nest and eggs of Wilson phalarope; 25. Black terns rising from lily pads, Tachick Lake. (Read figs. from left to right beginning at top.)

1944-45, saw a few in willow brush three miles north of Vanderhoof village, and several others near Sinkut Lake.

Pedioecetes phasianellus (Linnaeus), Sharp-tailed Grouse.—A small population of sharp-tailed grouse inhabits the Lakes District, another the region north of the Nechaco River at Vanderhoof. Both territories are eminently suited to the species, having grain fields, aspen woods, brushy coverts and many berry-producing shrubs.

A resident of the Lakes District reported seeing 18 fly into a field beside Nulki Lake on May 6. The only personal observations at this time were for single birds on May 8 and May 11. On June 28 a female with seven young was flushed near our cabin. This family, or another, was seen there occasionally until August 29. None was seen in 1946.

Perdix perdix (Linnaeus), European Partridge.—A number liberated in 1931 north of the Nechaco River at Vanderhoof increased to approximately 200 by 1933, then disappeared. Six pairs liberated in the Lakes District in 1929 increased to 40± by 1933; none was seen in the years following. The above information was obtained from Mr. Phil Brown and Mr. A. Dickson, Nulki Lake.

Grus canadensis (Linnaeus), Lesser Sandhill Crane.—A flock of 50± flew over Vanderhoof on April 27 (Brown) and on August 17 a flock of 200± flew south-east over Sinkut Lake. These are the only local observations.

Porzana carolina (Linnaeus), Sora.—Common, nesting in all of the larger marshes visited. The first were recorded on May 19, at Bradley's Slough, and on May 22 at Manson's Slough.

At Collins' Marsh, on June 14, a sora was flushed from a nest containing 10 eggs (Fig. 23). The nest, 10 inches in diameter, was compactly fashioned of small, dry sedges, including a round-stemmed and a flat-stemmed species. It rested on a slight elevation high enough to raise the base slightly above the water, which at this point was three inches deep. The surrounding vegetation, including mint, water buttercup and grasses, arched over and completely hid the nest, but when the plant-cover was bent aside the yellowish-colored nest immediately became conspicuous against the background of vivid green.

On June 27 at Manson's Slough a deserted nest containing one fresh egg was discovered. It was made of old, wet sedge stems, and was situated at the base of a sedge clump measuring four feet in height.

A population of approximately six pairs inhabited Bradley's Slough and during early summer members of the population frequently were heard at different places in the marsh. None was seen until June 24 when an adult ran out from the thick sedges at the water's edge, then returned to cover and moved about within a small radius continually making a short, creaking call. Undoubtedly this bird was attending young.

On July 10, at six different places where the marsh meets the open water, single adults emerged from the sedges and walked along the outer edge of this vegetation, sometimes belly-deep in water. Continually they uttered the

ordinary sharp cry on a single note. The loud, penetrating series of notes on a descending scale, persistently used in spring and early summer, rarely was heard at this time. Once or twice from the marsh came a querulous cry, such as a kitten might make. The first downy young was seen on this day, the unusual cry might have been made by its mother.

Adults continued to be relatively conspicuous during the remainder of July. It was observed several times (July 17) that two adults presumably a pair, travelled together through the marsh, rarely more than 30 feet apart and often much closer together. One would call and the other answer immediately; this was a continual performance. Occasionally one appeared at the margin of the sedges, then ran to cover. So also, but less frequently, did the small, black, orange-bearded young which the adults were attending. Adults and young were still present, and the adults still crying on July 30. On August 2 none was seen nor heard and it seemed evident that the adults, at least, had left the slough. The following day one full-grown young was seen, this being the last record for that place. None nested in this slough in 1946. The first autumn transient, a young bird, was flushed here on August 20.

At least two adults were heard at Tachick Lake, August 6, and one, age not determined, was flushed from a horsetail marsh on Sinkut Lake, August 30.

Fulica americana Gmelin, American Coot.—During the first week of May the majority of the coots then in the district were assembled in flocks on the larger lakes, the greatest numbers seen being 130 on Nulki Lake, May 5, and 100± on Tachick Lake, May 7. Smaller numbers were noted on the two principal sloughs, viz.: 12 on Manson's Slough, May 4, and 20± on Bradley's Slough, May 5. Later small nesting populations were found at various places and these were studied in more or less detail as indicated below.

Manson's Slough.—Four or five pair nested in the thick sedge growth where they were more often heard than seen. Two nests, each containing seven eggs, were found on June 16. One, 10 inches in diameter and made of dry sedges, was built in a clump of tall green sedge growing on the margin of an open pond. The other, 12 inches in diameter, was in a similar site and made of the same material. This nest, however, was in the dense marsh 50 yards from shore and about 200 yards from the nearest pond; the water in this part of the marsh, at that time, was three inches in depth. Ten feet from the nest a mound of desiccated sedge in a green sedge clump was partly concealed by a number of green sedge stems, broken about half way up so that they bent over the mound, and scattered over the top of the structure were numerous coot feathers and some droppings; this evidently was a resting place. At neither nest was a coot seen, but at the second one was heard nearby in the marsh.

One newly hatched young was seen on June 18, two others on June 27; in neither instance was a parent near them. On July 14 a pair with one small young, and one adult with one large young, were observed on open water. No coots were seen, or heard, subsequently. It was assumed that all left when, in early August, the slough rapidly dried out.

Bradley's Slough.—Three pairs, of the 20 or so individuals seen in early May, remained to nest. On June 1 five were together, the males displaying, and on June 7 each of the three pairs occupied a nesting territory — areas of open water, adjoining the sedge marsh, in which a pair or one of a pair was generally to be seen loafing or feeding. Several times one was observed dipping, in the manner of a pond duck, for food. One pair left the slough about June 30. The marsh in which the remaining two pairs of coots nested was boggy and impossible to wade, so no particular effort was made to locate the nests; however, one nest, situated on a sedge clump at the water's edge, was found on June 24. It measured nine inches in diameter and was made entirely of dry sedges, the upper surface four inches above the water. On June 24, the nest contained eight eggs. On July 6 it was observed that five eggs had hatched; one downy young swam close to the nest; one parent, on the water 30 yards away, clucked continually. Later this pair was seen on open water, accompanied on July 14, by two large young, and, on July 22, by three young. The male of the second pair disappeared a short time prior to July 14. On July 22 the female appeared on the water with three small young. Shortly after this the three remaining adults and most of the young disappeared. On August 2 only one coot, a well-grown young, was seen on the slough and none was recorded there after that date. None nested there in 1946.

Collins' Marsh.—Three pair nested in Collins' Marsh and two nests, each containing eight eggs, were located on June 15. One made of dry cattail was conspicuous at the base of a cattail clump in which no green spears showed above the water. The second was made of dry cattail which the coots had dragged into a patch of green sedges. The nearest source of supply was 75 yards away. From this nest a cattail ramp, two feet in length, slanted down to the shallow water. The third nest, measuring 10 inches in diameter and made exclusively of cattail, had been built in a cattail patch the top surface of the nest three inches above water. This nest was found on July 1 when it contained only one egg ready to hatch. The chick within apparently was too weak to break through, although it had succeeded in making a small hole in the shell. The egg was carefully opened and the chick liberated. A half-hour later it had revived sufficiently to move head and feet, but whether or not it survived was not determined. In this marsh, also, were a number of resting places — platforms of dry cattail soiled with droppings and containing a few coot feathers.

Tachick Lake.—A small population nested on Tachick Lake. On July 4 approximately 30, some in pairs, others alone, occupied territories that fronted on nesting sites along the north and the south shores. These observations were made from a motor boat. On July 8 the marshes at the west end of the lake, too shallow and weed-obstructed to be navigated by boat, were explored by canoe and the following census taken; one female with one young, others of the brood hidden in cattails; one female with five young, on open water; one pair with three large young; one pair, without young; two large young, alone; four large young, alone; one female, young hidden in marsh; one pair with three large young; one female with five large young. The total population of

adults, according to these observations, approximated 23 pairs. The counts were not subsequently checked and the population may have been larger than indicated. On August 6 a flock of 22 adults, a small number of well-grown young predominantly white below, and a female with one large young, were observed on a portion of the marsh. On August 9, 1946, half-grown to three-quarters grown young were plentiful, representing about 65 per cent of an estimated total population of 350.

Nulki Lake.—In a circuit of Nulki Lake by boat on July 24, only two families were observed, viz.: one pair with one small young, one pair with three large young.

Charadrius h'aticula Linnaeus, Semipalmated Plover. — At Bradley's Slough, August 16, 1946, a flock of seven alighted on the mud about 20 yards from shore, attracted there by a small flock of lesser yellow-legs. During the next 10 days members of the flock, or other individuals, were seen at Bradley's Slough almost daily, the last being recorded August 26. A single bird was also observed on a beach at Sinkut Lake, August 25.

Charadrius vociferus Linnaeus, Killdeer.—On May 2 two killdeer were observed at the mouth of Stony Creek where it enters the Nechaco River at Vanderhoof, and thereafter the species was recorded many times beside most of the waters visited, including a small shallow lake in the lodgepole pine forest on Sinkut Mountain. A pair nested and raised young in a field close to headquarters. On July 2 post-breeding adults were first noted on the margin of Bradley's Slough and this territory continued in use as a feeding ground and resting place for transients during the remainder of the summer. The largest number, 12, was recorded there on August 31. The sandy beach of Middle Bay, and the open field adjoining, also were resorts for migrating killdeer. In the evening of August 10 a flock of 10 was counted there.

In 1946 the first killdeer was seen on March 10 (Lakes District School record). The first indication of a southern migration was noted on August 17 when five young appeared on the mud at Bradley's Slough. After that date killdeer gathered there in larger numbers, e.g., August 21 — 23, August 28 — 17. As usual this species was a disturbing element in the wader population, taking flight with noisy cries and infecting other less wary species with equal degrees of nervousness. so that observations except at long range were sometimes difficult to accomplish.

Arenaria melanocephala (Vigors), Black Turnstone.—On August 29 an adult female in summer plumage was collected on the beach at Middle Bay. This bird was alone; no other waders were on the beach. So far as I am aware this is the second record for an inland point in British Columbia. the first being an immature specimen collected at Teslin in the summer of 1933.

Capella gallinago (Linnaeus), Wilson Snipe.—Four Wilson snipe were observed, May 2, feeding on a mud bar, where Stony Creek enters the Nechaco River; on May 5 four were flushed from a grassy slough at South Bay,

Nulki Lake, and 40± from the marshy edge of Bradley's Slough. These last rose singly, by twos and threes, in a wisp of 15 and another of nine. The following day approximately 20 were flushed from this slough. A single bird was heard in courtship-flight over an adjacent meadow at various times between May 19 and May 22, two weeks after the main flight had passed, and it was concluded this bird might be about to nest in the vicinity. Single adults were flushed from the meadow at Bradley's Slough on June 14, July 21 and August 3 but no satisfactory evidence of nesting was obtained either there or elsewhere in the district.

The first indication of an autumn migration was at Sinkut Lake, August 6, when one Wilson snipe alighted on a muddy beach. This bird stood motionless for some minutes, as if tired after a long flight. Again, on August 29, five were observed at the mouth of Stony Creek. In 1946 a total of seven was seen between August 20 and August 29.

Actitis macularia (Linnaeus), Spotted Sandpiper.—Not recorded until May 24 when one appeared on Bradley's Slough; another was seen at Nulki Lake, May 25, 26, and a third on the Nechaco River, May 28. Subsequently one or more were seen daily at Nulki Lake, and two pairs nested near our cabin. One half-grown young, guarded by one parent, frequented the beach after July 16. The local population left shortly before August 8. Afterwards single transients were recorded August 16, 22 and 24.

A nest built on a gravel bar in Sinkut Creek, and sheltered by an open thicket of willow shoots, contained four eggs on June 8, 1946.

Tringa solitaria Wilson, Solitary Sandpiper.—Noted as a transient in spring and late summer; no evidence of nesting in the district was obtained. In spring the species frequented shallow meadow sloughs, in autumn the muddy beach of Bradley's Slough and the margin of Sinkut Creek.

In spring a total of 12 was counted as follows: May 5 — 4; May 6 — 4 (2 couples); May 8 — 2; May 9 — 1; May 16 — 1.

On the southern migration the first, an adult, was recorded on July 5, the second, also an adult, on July 28. Later records, on the dates following are for young of the year: July 31 — 1; August 2 — 4; August 3 — 1; August 22 — 3; August 24 — 1.

Tringa solitaria solitaria Wilson.—One molting adult male taken July 28, 1945, is the only specimen record.

Tringa solitaria cinnamomea (Brewster). — One young female taken August 24, 1945, is the only specimen record.

Totanus melanoleucus (Gmelin), Greater Yellow-legs. — First recorded May 2 when one was heard whistling at Nulki Lake and another at Bradley's Slough. The largest number counted in one day during the spring migration was 10 on May 5 and again on May 8. Seen occasionally, and the courtship song heard, after the spring migration had passed, but no precise evidence of nesting was obtained.

Adults on the southern migration were identified with certainty in 1945

on June 29, July 1, July 19, and in 1946 on June 22, June 26 and July 3. All those seen later were young of the year, the first being recorded on July 16, the last on August 28, 1945. Bradley's Slough was the local feeding ground most frequented. Summer transients also were observed at Middle Bay, Sinkut Lake and beside a small lake in the lodgepole pine woods.

A clutch of eggs was collected on May 24, another on May 31, 1889, at Fort St. James (Mair and MacFarlane 1908).

Totanus flavipes (Gmelin), Lesser Yellow-legs.—Observed on the southern migration only, and recorded first, in 1945, on July 10, when five appeared on Bradley's Slough. These and all others seen later were young of the year. The peak of the migration appeared to be between August 2 and August 8 when it was usual to find seven or eight together on the beach at Middle Bay. The largest number counted in one day was 22 at Bradley's Slough, August 4; the latest record is of four birds on August 31. In 1946 an adult was recorded at Bradley's Slough on June 26. Young were observed at the same place as follows: August 16 — 22, August 17 — 16, August 19 — 10, August 20 — 5, August 22 — 5, August 24 — 2, August 28 —17.

As is generally so the young were easy to approach. Once I watched a single bird for five minutes perhaps, as it stood in the water with a large dragonfly nymph in its bill, grasped by the thorax. Five times the insect was shaken vigorously, dropped to the water, picked up, and shaken again. Then it was quickly swallowed.

Erolia melanotos (Vieillot), Pectoral Sandpiper.—On May 5 a flock of 30 was flushed twice from the boggy shore of Bradley's Slough, and on May 9 a flock of four was observed on a sand bar in the Nechaco River. A flock of 20 on a meadow slough at Nulki Lake, May 16, was feeding amongst flooded grass-clumps; these and a flock of six at Manson's Slough, May 22, showed little concern when I walked within a few yards of them.

During the autumn migration of 1945 an adult female in worn breeding plumage was taken, August 2, and one young was recorded August 31. In 1946 it was observed on the autumn migration as follows: Bradley's Slough, August 17 — 1, August 20 — 2, August 24 — 2, August 26 — 1; all were thought to be young of the year.

Erolia bairdii (Coues), Baird Sandpiper.—Young of the year were observed in 1946 as follows: Bradley's Slough, August 20 — 4, August 26 — 2, August 28 — 1; Sinkut Lake, August 23 — 2. Two specimens were taken.

Erolia minutilla (Vieillot), Least Sandpiper.—Two records in spring, viz.: four beside a flood-pond in a cultivated field, May 5, and one at Manson's Slough, May 22.

The first of the south-bound migrants to arrive were adults, three on July 11, 5 on July 16, 3 on July 18, 1 on July 19. All seen later were young; the first, a single bird was recorded on July 31, the second on August 2. Later the species became relatively common; the largest number counted in one day was 20, on August 5. The last was observed on August 31.

In 1946 an adult was recorded at Bradley's Slough, June 26, and young

of the year were observed as follows: Bradley's Slough, August 16 — 4, August 17 — 5, August 19 — 4, August 20 — 4, August 21 — 4, August 24 — 5, August 28 — 1; Sinkut Lake, August 24 —2; Nulki Lake, August 17 — 7.

Limnodromus griseus (Gmelin), Dowitcher.—On July 14 a flock of 10 adults, all busily feeding along the muddy margin of Bradley's Slough, was approached within a few feet — by canoe. Another flock of 12 adults was observed on a muddy stretch of Manson's Slough in the evening of that day. Smaller numbers, all adults, were seen at Manson's Slough, Nulki Lake and Sinkut Lake, up to July 31.

An adult accompanied a feeding flock of lesser yellow-legs at Bradley's Slough, August 28, 1946, and this dowitcher, or another adult, was observed, August 22, feeding with a flock of seven young of the species.

Two females collected July 14, 1945, are in worn summer plumage; neither had a brood-patch. These are identified as *Limnodromus griseus scolopaceus* (Say).

Ereunetes pusillus (Linnaeus), Semipalmated Sandpiper.—One spring record, viz.: three at Bradley's Slough, May 24. The first autumn transients, a flock of eight, on Bradley's Slough, July 16, were adults in worn breeding plumage. An adult male collected had well-marked brood-patches. Two birds on the beach at Nulki Lake, July 24, were thought to be adults also. The first young, three in a flock, were recorded at Sinkut Lake, July 31. Soon after the species became common and was seen frequently at different lakes, the last, a flock of 10, on August 31.

In 1946 a migration of young was observed at Bradley's Slough, August 16 to 28. Next to the killdeer this species was the commonest wader, noted as present in small flocks totalling 10 to 30 each time the slough was visited.

Ereunetes mauri Cabanis, Western Sandpiper.—At least two individuals of this species associated with flocks of semi-palmated sandpiper at Bradley's Slough, August 20, 22, 1946. One specimen was taken.

Tryngites subruficollis (Vieillot), Buff-breasted Sandpiper.—On August 17, 1946, at Bradley's Slough, a buff-breasted sandpiper was observed running along the outer edge of the wide mud flat that encircled the slough, and occasionally coming in shore amongst the stranded arrowhead. A specimen of this species, probably the same individual, was collected at the same place on August 19. It proved to be an adult female.

This species has not hitherto been recorded from interior British Columbia.

Crocethia alba (Pallas), Sanderling.—On August 23, 1946, an adult male of this species accompanied a single semipalmated sandpiper on a small beach where Sinkut Creek enters Sinkut Lake. This bird was collected.

Steganopus tricolor Vieillot, Wilson Phalarope.—First recorded May 27 when I had an unobstructed view of an adult female on one of the ponds in Manson's Slough. On June 3 at Collins' Marsh a male was flushed from a nest containing four eggs (Fig. 24). The nest, a shallow depression in the ground lined with a small amount of dry grass was concealed effectively by

dandelions and other vegetation. Later a male, at another part of the marsh, behaved as these birds do when nesting, that is, it circled about not far above the ground and continually uttered a soft cry. No females were observed in the vicinity. So far as I am aware this is the first nesting record for British Columbia north of Cranbrook based on the finding of nest and eggs.

No adult females were recorded on the southern migration. On July 8 three post-breeding adult males were active on a large patch of yellow pond lily leaves at Tachick Lake, where they were feeding on damselfly nymphs. The last adult male was recorded on July 12. On July 24 a flock of 11 young of the year was flushed several times from lily pads at the west end of Nulki Lake. The latest record is for one young, Nulki Lake, August 6.

In 1946 it was recorded once only, viz.: an adult male at Tachick Lake, August 9.

Lobipes lobatus (Linnaeus), Northern Phalarope.—On June 18, and again on June 20, an adult male and female in breeding plumage were observed swimming close together on Bradley's Slough. A flock of 15 on Nulki Lake, August 25, and three on Bradley's Slough, August 26, are the records for 1946.

Larus argentatus Brunnich, Herring Gull.—Herring gulls were present on Nulki Lake, May 2, before the ice went out, and no doubt had arrived earlier than this. All summer a small number frequented North Bay where they rested, hours at a time, on a log boom and on a number of dolphins standing about 75 yards from the shore. Fourteen was the largest number seen in one day, June 7. This population included adults, and immature birds in various stages of molt. No young of the year were seen there. Several times during the first two weeks in July a very small herring gull, a bird in the second year, was inspected closely through binoculars. This individual had the characteristically small bill of *Larus argentatus thayeri*.

Some of the gulls that frequented North Bay were seen several times circling over the open fields as though hunting the abundant meadow voles. At other times single birds were observed tearing at floating dead fish and once, at Bradley's Slough, an adult industriously tugged at the few remaining shreds of muscle on the skeleton of a horse which had gone through the ice in winter. A few pellets, gathered from the tops of the dolphins at North Bay, were composed of debris from the following two items, viz.: fishes and mice. One contained the pharangeal teeth of a small squawfish and bones of a much larger fish, not identified; another contained a pharangeal plate and other bones of a small squawfish, and four incisors and some hair of a microtine; the third was made up of bones representing small fishes, and the femur of a mouse.

On June 25 an immature herring gull, at Bradley's Slough, identified as being in its third summer, was watched as it hovered over a brood of downy bueffle-head. Several times it slanted down towards them but, so far as I could see, failed to seize one. This took place at too great a distance to observe the precise reaction of the ducks thus attacked.

During a trip by gas boat on Stuart Lake, July 26 and 27, approximately 30 adults were recorded. Each of three rocky islets was occupied by 8 to 10

adults. Possibly the islets are nesting places but this was not determined as our boatman did not care to approach the islands too closely, and we had no other means of landing on them. On August 10 fifteen adults and two young of the year were together on a muddy beach opposite the Hudson Bay buildings at Fort St. James.

Larus californicus Lawrence, California Gull.—On August 10 two juvenile California gulls in dark unworn first-plumage stood amongst a flock of 17 herring gulls on a mud beach at Fort St. James, Stuart Lake. The California gulls, conspicuously darker than two herring gulls of about the same age that stood near them, were examined through binoculars at a distance of about 100 feet. A bird of the year was identified by a close sight-observation at Sinkut Lake on August 28, 1946.

Larus delawarensis Ord, Ring-billed Gull.—At North Bay, Nulki Lake, June 12, 1946, two adult gulls of this species stood on the dolphins amongst a number of the larger herring gulls. They were examined carefully through binoculars. A single bird of the year came under close observation both in flight and on the water at Sinkut Lake, August 27.

Larus canus Linnaeus, Short-billed Gull.—On May 6, at 11:30 a.m. I counted 75 short-billed gulls that stood on a floating log in North Bay, Nulki Lake, and in the late afternoon of that day about 40 were observed soaring over a stubble field near that place; in the evening of the same day approximately 40 visited Middle Bay. Two days later 60± were observed on the Nechaco River. No others were recorded in spring. In late summer young in first plumage were seen as follows: Sinkut Lake, August 25 — 3, August 26 — 1; Nulki Lake, August 29 — 1.

Two juveniles were recorded at Sinkut Lake, August 14, 1946, and on August 23 a flock of 40± adults alighted on Bradley's Slough close to a raft of pond ducks with which they mingled. The gulls, exceptionally wary, left the slough while I was yet 200 yards from them.

Larus philadephia (Ord), Bonaparte Gull.—First seen on May 2 when a flock of 13 rested on the ice on Nulki Lake. From that date until May 15 the species was seen frequently, the largest flock counted being 73, Bradley's Slough, May 8. In the morning of May 16 eighteen rested on a floating log in company with short-billed gulls, and later that day two adults, and two young without black on the head, visited Middle Bay. A flock of 200± on Tachick Lake, May 20, is the last spring record. Except for a single adult on June 19 none was recorded subsequently until the southern movement commenced in August. The fore-runners of the southern migration were one adult and one young on North Bay, August 6, and a flock of seven on Sinkut Lake, August 7. The first large flock, 300± adults and young, visited Nulki Lake on August 13; the second, 200±, chiefly young, was recorded at Sinkut Lake, August 20.

In 1946 a flock numbering 22 to 30, on different days, arrived on Bradley's Slough, June 12, and remained there until June 27. Two appeared to be

adults, the remainder in the winter plumage of juveniles molting to adult plumage. During the 15 days the gulls remained on the slough the progress of the molt was plainly visible. A progressive darkening of the head took place as more and more black feathers appeared on this area. A specimen taken on June 17 is more than half black on the crown, and speckled with black on chin and throat, the mantle is freshly molted, the wings those of a juvenile, very much abraded.

A flock of 25, young of the year, appeared on Sinkut Lake near the mouth of Sinkut Creek on August 19. Some stood on a small beach, others flew back and forth across the lake's shallows. These or others, together with some adults, were seen there subsequently a number of times up to August 28. A total of 40 counted there August 27 included both adults and young, some of the last seemingly not long out of the nest.

Transient flocks also visited Bradley's Slough at this time, 25 on August 24, 200± on August 26, and 100± on August 28.

Reported nesting beside a lake about 30 miles east of Fort St. James where four eggs were collected on June 13, 1889 (Mair and MacFarlane 1908).

Chlidonias nigra (Linnaeus), Black Tern.—Recorded first on May 22 when two circled over Manson's Slough; again on May 26 at 11:00 a.m., when 12 flew west over Nulki Lake. Later a number of nesting colonies were discovered, some larger than any of those known in southern British Columbia.

The members of a colony nesting in Manson's Slough, estimated to number 35 pairs, constantly travelled between that place and Nulki Lake, where perhaps most of their food was obtained. Numerous times at Manson's Slough an adult was seen carrying a small fish in its bill, which could have come only from Nulki Lake the nearest waters containing a fish population. Members of this colony were seen hunting food, probably odonata nymphs, on Bradley's Slough. Few young were raised and so late as July 14 only adults flew over the marsh. These acted in the manner customary to nesting black terns, some being perfectly fearless in their swooping attacks as I waded the marsh; one actually struck me sharply on the head. On July 28 it was observed that some adults had left, amongst the remainder were several showing the first indications of molt to winter plumage. Four flying young, the first seen, were recorded on that day. On August 9 only five adults and four flying young were present and when the slough was next visited, August 22, all had left.

A large colony, possibly 100 pairs, nested in the marshes at the west end of Tachick Lake. On July 4, during a complete circuit of the lake, adults in small numbers, no doubt from this colony, were observed hunting food at many places. On July 8 part of the colony, approximately 100 adults, flew over the marshes carrying food in their bills; others rested on the large patches of yellow pond lily. Figure 25 shows the last of a flock rising from the lily pads; other adults cruised along the shore. When this place was next visited, on August 6, approximately 200 young were present; most of them resting on the floating lily pads. All but about 20 adults had left.

Another colony, possibly even larger than the last, occupied the marshes at the west end of Nulki Lake. Here on July 24 the numbers present were estimated to be 150 adults and 40 flying young, and on August 6 eight adults and 250 flying young. On the last date a flock of 75± circled over a flock of Bonaparte gulls on Middle Bay.

Other smaller colonies probably nested at the east end of Tachick Lake, and at the west end of Sinkut Lake where adults were seen regularly during the summer.

No adults were recorded after August 6; the latest date for young is August 20, when 20± were seen in flight over Sinkut Lake.

Three, probably transients, visited Bradley's Slough, June 10, 1946, but none was seen there subsequently. Only an occasional one or two were recorded elsewhere in the district during June. In August, at Tachick Lake, black terns were much less common than they had been during the same period in 1945, only 30 adults and young being recorded there on August 9.

Evidence of a southern migration was noted first at Sinkut Lake on August 19, when an adult in summer plumage and three young flew along the marshy shore at the mouth of Sinkut Creek. Twelve young and one adult were there on August 25, and on August 27 at least 150 in one flock milled about, 100 yards or so above the water.

The following day only half that number were present, some resting amongst lily pads, others in flight up and down the beach. All seen on the last two dates were young of the year.

Zenaidura macroura (Linnaeus), Mourning Dove.—Mr. and Mrs. Robert Collins told me that a mourning dove visited their place, on the north shore of Nulki Lake, in the summer of 1943, and remained there several days feeding with their fowls. Both observers were acquainted with this bird in the eastern United States.

Bubo virginianus (Gmelin), Horned Owl.—Seen or heard frequently at many places in 1945; the number of nesting pairs in the Nulki Lake region was estimated to be one to the square mile. In July and August one, and sometimes two, hooted nightly beside our cabin, and in the dusk or on moonlight nights one of them often was seen on the ridge of a barn, or on top of an aspen by the lakeshore. On the night of August 28 it was observed that one perched on the aspen and, clearly outlined against the sky, leaned forward and raised its tail each time it hooted.

On August 3, a day of bright sunshine, a young bird still partly covered with down, stood at the center of a fallen aspen that bridged Sinkut Creek. A few minutes later another of the same age was seen in a cottonwood tree nearby.

Two of four pellets examined consisted of rabbit fur and rabbit bones; another was composed of a foot, a lower mandible and feathers of a male mallard; a third was made up of feathers and bones of a diving duck, probably a buffle-head.

Later it was learned that horned owls became even more plentiful in the autumn of 1945, and during the ensuing winter months, than they had been

in the summer — the population undoubtedly being reinforced, or perhaps replaced, by an invasion from elsewhere. Many were killed; one trapper at Sinkut Lake reported taking 17.

In 1946 none was seen or heard by me during June and early July, neither were any seen by a number of local residents whom I questioned on the subject. A few commenced to enter the region about Nulki Lake in early August; two were heard answering each other's calls on August 8, and these or two others again on August 17. On August 20, on the mud alongside Bradley's Slough, I found four places where ducks had been plucked — two which were close enough inshore to permit examination of the feathers proved to be baldpate. This predation was attributed to horned owls.

The abundance of horned owls in 1945, and their scarcity in 1946, can perhaps be co-related with a change in the numerical status of snowshoe rabbits, viz.: not uncommon in 1945 and very scarce in 1946. This reduction in the numbers of rabbits, occurring during a time when theoretically the species should be increasing, probably can be attributed to heavy predation pressure by horned owls.

The autumn and winter invasion referred to evidently extended some distance south as horned owls were reported more than usually abundant in the Horsefly District. Here Mr. Fred C. Hooker trapped 50 in the winter of 1945-46.

Nyctea scandiaca (Linnaeus), Snowy Owl.—Reported as an occasional winter visitant to the Lakes District. Several times in the winter of 1944-45 Mr. George Evans saw one feeding on offal that had been set out in a field as coyote bait. I examined a foot and some feathers of a snowy owl found in the winter of 1945-46 by a pupil of the Lakes District school. According to the story told me this owl was eaten, and presumably had been killed, by a large raptor, probably a golden eagle. The eagle was flushed from the ground where it had been seen feeding on the owl.

Surnia ulula (Linnaeus), Hawk Owl.—One collected at Fort St. James in 1889 (Mair and MacFarlane 1908) is the only record known to me.

Glaucidium gnoma Wagler, Pygmy Owl.—This owl is rare in central British Columbia. On Sinkut Mountain, August 23, one came to an imitation of the species' call and perched about 35 feet above ground in a lodgepole pine, almost directly above where I stood. Possibly this was a transient because repeated use of the pygmy owl call at many places both in 1945 and 1946 failed to bring a response.

Strix nebulosa Forster, Great Gray Owl.—Two specimens collected by W. E. Trall at Stuart Lake in September, 1891, are in the Provincial Museum, Victoria. These are the only records.

Asio otus (Linnaeus), Long-eared Owl.—On June 9 I examined a crow's nest in which, earlier in the year, an owl had raised five young. The nest was found, by one of the local residents, in late April when it contained five eggs. The site was 15 feet from the ground in an eight-inch Engelmann

spruce, one of several larger trees in a thicket of this species growing along the side of an open grassland. The nest, the characteristic stick type, probably was several years old, its nearly flat top covered with dry spruce needles and a little dry moss amongst which were numerous tibial feathers of the long-eared owl. Some of these were collected and later compared with feathers on a museum specimen. Egg shells, including one about three-quarters intact, were scattered on the mossy ground below the tree. The eggs when whole would have measured approximately 40 x 35 millimeters.

Diligent search for pellets in the spruce thicket revealed only four, the largest about 50 millimeters in length. All contained skulls, bones and fur representing *Microtus pennsylvanicus*. In addition one held parts of a beetle, three small pieces of stone, and plant debris, possibly fragments of oat husks. These items could have been from the gizzard of a bird that had been eaten.

The character of the nest, the presence of long-eared owl feathers in it, the dimensions of the egg shells and the size of the pellets cast near the nest, is deemed evidence sufficiently conclusive to establish a breeding record for this owl. If correct it would represent the most northerly record not only for the nesting but for the occurrence of the species in British Columbia.

On August 16, 1946, I flushed a long-eared owl from the trunk of an upturned tree in a meadow, close to where the nest had been in 1945. It alighted again not far away on a stake driven into the ground, thus enabling me to examine it through binoculars, which I did for about 10 minutes. From this perch the owl flew into a neighboring wood and was not seen again. The observation would seem to add verification to the nesting record of the species at Nulki Lake in 1945, as detailed above.

Asio flammeus (Pontoppidan), Short-eared Owl.—In the evening of May 6 a short-eared owl was seen for several minutes in flight over a field at Nulki Lake. Several times it passed me within a few yards; there could be no mistake as to its identity. This is the only record.

Aegolius funereus (Linnaeus), Richardson Owl.—The dried-up carcass of a Richardson owl was found near a barn close to Nulki Lake. No other information relating to the probable occurrence of the species was obtained.

Aegolius acadicus (Gmelin), Saw-whet Owl.—The bell-call of the saw-whet owl was heard occasionally in the evening and at night during the latter part of May. Early in the morning of June 3 the familiar notes came, at short, regular intervals, from an aspen wood about one-half mile from our cabin. I set out to trace the sounds to their source and, directed by them, did so without difficulty. The owl was calling from the entrance to its nest in an aspen stub. Subsequently observations were made there, usually once each day, until August 8, when, for a reason given later, a family of young owls was removed and kept in captivity until August 26 when they were full-grown, or nearly so.

All the details of observation, as set forth below, were not obtained consecutively; the pattern of reproduction and behavior was pieced together from evidence obtained at different times. For example, it was not known when

the nest was found whether it was empty, or if it contained eggs or young; neither was it known that the vocal owl was the male. Examination of the nest and its contents was delayed until June 19 because it was feared that the preparations necessary to reach it might cause the birds to desert. The stub swayed at a touch and in order to reach the nest it was necessary to build a tripod-ladder and install it within arm's reach. It was necessary also to enlarge the nest entrance by cutting before a hand could be inserted. It was considered that by this date, that is, June 19, the eggs would be hatched and desertion by the parents less likely. However, although the clutch was incomplete on this date the fear of desertion proved groundless.

Nest.—The nest was a flicker's excavation, the entrance two feet from the top of an eighteen-foot aspen stub that measured approximately 16 inches in diameter at the base and which stood 100 feet from the outer edge of an aspen wood bordering a field under summer-fallow. The nest cavity, below the entrance, measured approximately eight inches in depth and 10 inches in diameter. The bottom was filled with soft, fibrous wood fragments. The outer shell of the stub at this point measured slightly less than two inches; the wood was hard and difficult to cut with a knife.

Incubation.—Four eggs were laid prior to June 19, and a fifth egg between that date and July 2. Two eggs had hatched by July 13, two others by July 15 and the fifth on July 17 or 18. Thus it would seem that, allowing a maximum 30-day incubation period, the first egg had been laid not earlier than June 13. When the nest was discovered on June 3, and the male was calling from the nest-entrance it would seem probable that laying had not commenced.

Behavior of Parents.—On June 3, when I located the nest, the male was standing in the nest cavity, his face filling the entrance (Fig. 26). From 8:30 a.m. to 9:00 a.m. he did not move from this position and every few minutes gave the bell-song, first hitching himself slightly upward and forward so that his head partly emerged from the entrance and revealed an inch or so of throat. The song started with 10 or more rapid beats, slurred together and of little volume so that the sound could be heard only at close range. This was followed, without pause, by a regular and resonant series of beats on a higher note and at a slower tempo. Once 56, another time 72, beats followed the soft, introductory phrase. This portion of the song, it was noted later, could be heard at distances over a mile. In several of these performances two or three slight pauses occurred; more often the performance was uninterrupted. During the song a regular pulsation of the throat was visible from where I stood. At another time when the bird was more exposed it was seen that the entire diaphragm pulsated in rhythm with the song. The song completed, the face was withdrawn slightly so that as before it filled the entire circumference of the nest-entrance. Sometimes the bird stared down at me, its wide-open eyes showing the full circle of the yellow irides; again it looked sleepily ahead, eyes blinking, sometimes partly closed. The first aspect suggested anger and alertness, the second sleepy indifference. At no time did he show alarm at my nearness. Once the sound of a bird call in

a distant tree caused a quick, upward glance; again some slight sound from below brought scrutiny of the ground. I returned to the nest at 12:00 noon and remained there until 2:00 p.m. The male was in a spruce thicket about 200 yards from the nest and calling at intervals. In a few minutes he returned to the nest-entrance and called for about 20 minutes. Then he dropped out of sight in the nest, remained there for several minutes, reappeared at the entrance and gave two series of beats softer than usual. He then flew out and, after pausing momentarily on a nearby aspen, disappeared into the woods. A moment later I heard his song from a distance.

When I looked again at the nest entrance it framed the face of another saw-whet owl, obviously the female, and it was apparent that while the male was calling at the nest entrance the female had been in the nest below. The face of this bird seemed smaller than the face of the other, and the two birds readily could be distinguished. She stared at me with irides fully revealed. Several times she blinked but not once did she relax to sleepiness as the male had done. She made no sound, and at no time in the days that followed did the female call, or make any sound except that produced by the clicking of her bill. In 20 minutes or so the male suddenly reappeared in an aspen close to the nest entrance and twice gave a low tremulous call. He then flew to the entrance and the bills of the two birds appeared to touch. He fluttered away again, reappeared in a few moments and again touched bills with the female. After this second visit he alighted low down in an aspen about 30 feet from the nest and remained there for several minutes. Sometimes he followed my movements with wide-open eyes (Fig. 27). Again, he relaxed completely with eyes half-shut (Fig. 28). It was not until I broke off a dead aspen twig, beside which he was standing, that he moved. He flew to the nesting stub, gave the soft tremulous call, then left suddenly and disappeared into the woods. The female was still at the nest entrance when I left at 2:00 p.m. At 8:00 p.m., after a heavy rain storm, the bell-song came clearly from the distant woods; the soft prelude could not be heard.

Until June 9 the male was seen daily, in the nest-entrance (while the female was in the nest cavity below), or in the surrounding aspens; or he was heard calling in the woods. If absent from the vicinity of the nest he returned quickly after an imitation of his call was made several times. When near the nest the soft, murmuring call (not to be confused with the prelude to the bell-song) was given frequently, and for longer periods than before. Often it was followed by the loud, clear bell-song, to which his body moved in rhythm. On June 6, with face framed in the nest-entrance, he called continually from 10:00 a.m. to 11:00 a.m.

The male was not seen after June 9, and was heard only once, on June 14. However he must have been in the vicinity because, as it was later discovered, the last egg was laid sometime between June 19 and July 2. The female was almost constantly on the nest in the daytime. She was seen in the surrounding aspens once on June 8 (Fig. 29), and again at dusk, in company with the male, on June 9. Her behavior during our subsequent visits to the stub varied but little. She would hear our approach and come to the entrance, or, she might not appear until the stub was struck several times. Sometimes

Figs. 26-31: 26. Male saw-whet owl at nest entrance; 27. Male saw-whet owl, alert; 28. Male saw-whet owl, relaxed; 29. Female saw-whet owl in aspen near nest; 30. Two young saw-whet owls; 31. Young saw-whet owl with mouse. (Read figs. from left to right beginning at top.)

she would watch silently during the period of our visit; other times she would watch for a few minutes, then drop out of sight into the nest cavity. At no time did she leave the nest of her own accord. On three occasions she was ejected in order that the young might be taken out and photographed.

On July 18 numerous ants entered the nest and attacked the young. In order to save the young birds it became necessary to take them out of the nest and remove the attached ants; one owl had 16 ants, the others smaller numbers, securely attached by their jaws to the skin. It was necessary to use some force in order to remove them. Precautionary measures were then taken. The nest cavity was thoroughly sprayed with pyrethrum in kerosene, bands of molasses mixed with formalin were painted on the stub and chlorinated lime was spread around its base. These precautions proved effective. During the time this work was in progress the female looked on in silence. When the young were replaced in the nest she immediately attempted to enter but was repelled for the moment by the fumes of the fly spray. She entered after a few moments' hestiation and almost immediately came to the nest-entrance and watched us until we left the scene.

Appearance and behavior of young.—When first hatched the young were covered with white down; the eyes were closed. By the fifth day the naked areas between the feather tracts had expanded and the amount of naked area was greater than the area covered with down; the heads were large in proportion to the body, the bellies protuberant, the eyes still closed. At ten days the eyes were partly open, the irides dull-colored. On the fifteenth day the eyes were wide open, the irides pale olive, wing and tail feathers partly broken from their sheaths, and the contour feathers frosted with down. On the twenty-second day the young were about two-thirds grown, naked bellies protuberant, the irides olive-yellow. On the twenty-sixth day the full juvenile plumage had been attained; down was restricted to the head; the irides were clear yellow. The above description applies to the two oldest birds; the development of the other young followed the same pattern. By the first week in August the young owls were large enough to fill the bottom of the nest. It was observed that one or two stood upright while the others lay prone on their bellies. By this time the nest was fouled and ill-smelling.

On August 8 it became apparent that the female had either deserted the nest or had been killed. The young had not been fed for more than 24 hours; their bellies were flat and there was no food in the nest. Accordingly the five young owls were removed and placed in a screened box in our cabin. The box was left open for several hours each day so that the owls might leave it for the comparative freedom afforded indoors. On August 9 the two largest owls were taken outside and photographed (Fig. 30).

The owls were fed on mice exclusively. On the first feeding it was necessary to open their bills and place food between the mandibles. After receiving it they gulped down the small fragments with an accompanying of backward and forward movements of the body. On the second feeding, the following day, four took food when held to their bills. On the third day they picked up portions of mice placed in the cage. After the fourth day they were given half or whole mice, depending on the available supply. If the mouse was

small it would be swallowed whole; larger ones were torn to pieces and swallowed piece-meal. A difference in disposition was apparent; one of the smaller owls when given a mouse would immediately begin to tear at it; each of the others when fed would seize the mouse with its claws and stand over it, sometimes remaining an hour or more in this position before beginning to feed. The mouse was grasped in one foot, the claws piercing the tissue so deeply that it could not be removed without force (Fig. 31). One bird flew across the room several times carrying a mouse pendant from one foot. Pellets were thrown up nine or ten hours after feeding. This action was preceded by a number of "yawns" with wide-open bill. All the birds liked to drink; when water was held before them in a spoon they dabbled their bills in it with evident satisfaction and apparently were able to obtain water in this manner.

By August 16 the two largest could fly well and moved freely about the cabin perching on one object after another, sometimes on the floor, sometimes on the wall. Their plumage was clean and well kept. They continued to be completely fearless. When stroked they closed their eyes as though the sensation was pleasing.

On August 26, when the three largest were practically full-grown with no trace of down on the plumage, all five were liberated in a large granary in which house mice were plentiful. That night three owls left and were not seen again. Four days later one of the remaining two died, apparently from inability to feed itself; the dead bird was emaciated and the viscera shrunken. The other owl was seen several times with captured mice and was still in the granary when it was last visited on September 1.

Voice of young.—On July 18, when the two largest owls were five days old, I held the five in my cupped hands. Two birds made a soft, trilling sound for several seconds. Later, when the birds were in captivity, this soft call was heard many times but only from two of them. Invariably it was given when two struggled for the possession of a mouse. The three other birds made no vocal sounds at any time, so far as could be detected; when excited they rattled their mandibles together.

Food.—No food other than shrews and mice was found in the nest. Usually only two or three animals, whole or parts, were present, but on July 23 the following items were in the nest, viz., 1 *Sorex cinereus,* intact; 2 *Zapus princeps,* minus heads, and the hindquarters of a third; 3 whole *Peromyscus maniculatus,* young, another minus head and forelegs, and hindquarters of two others; 1 half-grown *Microtus pennsylvanicus.* Three *Clethrionomys gapperi* also were found in the nest at different times.

Pellets in the nest, of which 12 were examined, represented animals of the species noted. No pellets were found in the woods although considerable searching was done.

A specimen of the flea *Ceratophyllus niger* Fox was collected from one of the young owls in the nest.

Chordeiles minor Forster, Nighthawk.—The first nighthawks, one or two, were seen June 6 at 12:00 noon flying over open fields at Nulki Lake; a few passed through during the next five days and on June 12, apparently the peak of the migration, a dozen or more were in sight at once. During the nesting season nighthawks were recorded less often, usually not more than one or two during an evening. The first southbound migrants, 10, appeared August 8, 1:00 p.m. to 2:00 p.m., a smaller number on August 18, and on August 20 the main flight took place—when 20 were in sight at one time.

Again in 1946 the peak of the spring migration was June 12, when six were seen during 10 minutes in the forenoon and others later in the day.

Nephoecetes niger (Gmelin), Black Swift.—The first black swifts, 10 to 12, were observed at Nulki Lake on June 10, 6:30 p.m. These were flying into a strong westerly wind; the sky was clear. A migration on June 11, a day when heavy clouds caused the swifts to fly at low altitudes, lasted for over an hour and involved the passage of perhaps 500 birds. On June 12 and June 14, days of bright sunshine, several were observed high in the air. The only observation of the species in summer was on July 15 when a small number hawked over Nulki Lake during a rain storm.

Selasphorus rufus (Gmelin), Rufous Hummingbird.—Nested throughout the district, more commonly in the spruce-dotted willow bottoms than elsewhere. The first was recorded on May 9, the last adult male on July 4; the last individual was seen, flying across Stuart Lake, on July 27.

A nest saddled on the lowest branch of a small, live Engelmann spruce, one of several growing close to Sinkut Creek, was situated 14 inches from the trunk and four feet above ground. It contained two well-grown young on June 25. This was used as the foundation for a nest in 1946; the double nest, more than commonly graceful because of the added height, was completely covered with greenish-gray lichen. It contained two newly-hatched young on June 9.

On June 10, 1946, a nest built in a live Engelmann spruce, which stood beside a trail through the woods, contained two eggs. The site was five feet above ground, the nest pensile on a drooping branch, not saddled on it in the ordinary manner. Old man's beard thickly covered with lichen composed the outside, and felted cotton, probably from a cottonwood tree, the inside of the nest. The eggs presumably hatched that day, for it was seen on June 12 that both of the two blackish young were already marked with two lateral stripes of buff-colored down. On this day both parents were seen momentarily; neither defended the nest.

The site of another nest was the fork of a slender spruce twig, six feet above ground. The tree stood in deep shade amongst numerous other Engelmann spruce. The nest was scaled on the outside with lichen; the lining, where it stood above the main bulk of the nest forming a conspicuous rim, was flecked with small pieces of golden moss. It contained one egg on June 12; this was hatched by the following day. As I approached the nest on that day the female was brooding and she did not leave until I had come quite

close. On a subsequent visit, June 29, the female was not seen. By this time the single young filled the nest-cup (Fig. 32). The following day, or the next, it left the nest.

The three nests described above were in shaded woods; the greater part of the local population, however, was nesting in willow-bottoms—those not occupied by calliope hummingbirds. Thus, June 15, on one such place of 50 to 60 acres I counted seven males on territory-perches. Undoubtedly a larger number was using this particular willow-bottom.

On June 22 it was noted that males had become scarce and none was recorded after that date. No rufous hummingbirds of either sex were observed on August 7, when I returned to the Lakes District, and the only subsequent observation of the species was of one young male on August 10.

Stellula calliope (Gould), Calliope Hummingbird.—None was seen in the Vanderhoof Region in 1945, but in 1946 the species was relatively common there. Thus on June 16 six males were counted on a 10 to 15 acre tract of bottomland covered by willows which in 1945 was occupied by rufous hummingbirds. Here and there in the willow thickets tall, bare sticks stood high above the massed green shrubbery. These were used as perches and from them the males would dart forth and return again. Many such perches continued to be occupied during the following two weeks.

Elsewhere in the district the same kind of territory-perches were in use, apparently to the exclusion of other similar and nearby perches, for example: a tall stick standing upright in a willow thicket at the edge of a meadow was the exclusive perch of one male; a similar stick, amongst live willows, aspens and a few small Engelmann spruce, 100 yards distant, the exclusive perch of another. The first was observed to be in constant use from June 8 to June 18, the second from June 11 to June 18. I found no females on any of these territories, nor did intensive search reveal a nest. Males on territories were last seen June 27.

At no place were calliope hummingbirds and rufous hummingbirds found occupying the same tract of land. The preference of the first appears to be a habitat of fairly open willow-bottom, while that of the second includes this type of habitat as well as spruce woods and aspen woods.

Megaceryle alcyon (Linnaeus), Belted Kingfisher.—First seen May 5, one at Nulki Lake, another at Bradley's Slough. Later others were recorded at Tachick Lake, Sinkut Lake, the west end of Nulki Lake and elsewhere. Apparently it nested at all these places. One nest at Nulki Lake was in a 20 foot eroded bank above a narrow beach. No young was observed and at the end of August the population seemed no larger than it had been in May. It was suspected that the young were killed in the nest by *Protocalliphora* maggots. The nest was not occupied in 1946.

Colaptes auratus (Linnaeus), Yellow-shafted Flicker.—A small population was established in various aspen woods when I arrived in the Lakes District on May 1. Members of this local population were seen or heard frequently

until August 1; shortly afterwards all disappeared. Three, assumed to be transients, were recorded August 21-22 along the Lakes District-Vanderhoof road and on August 25 a migration of 10 to 12 birds was observed there.

Yellow-shafted flickers also were noted on May 7, at Fraser Lake, Nithi Valley and at the east end of Francois Lake.

A pair nested in a two-foot high aspen stump, the nest entrance four inches from the top. This was one of numerous similar stumps on an open knoll which had been cleared some years ago and is now grown over with shrubbery. On June 24 the nest contained eight half-grown young. Another nest, near the top of a dead cottonwood about 50 feet in height situated beside the shore of a small lake in lodgepole pine woods, contained young on July 2. A third nest, 20 feet above ground in a 10 inch, live aspen near the edge of a meadow, contained six naked young on June 11, 1946. On June 28 they were about two-thirds grown and well-feathered; the young left the nest on July 1. The male parent, observed at close range, was noted as a typically-colored *auratus* except that the malar stripe was red. Very often flickers were observed on the ground feeding upon ants, which were everywhere in enormous numbers. The stomach of each of two adult flickers, taken May 9, contained ants exclusively; the gullet of another, taken July 2, was filled with a mass of ant larvae and pupae; one of two flying young, taken June 23, had eaten ants, the other had eaten black twin-berries.

The flickers inhabiting the portion of central British Columbia under review are *Colaptes auratus* with a slight and varying admixture of *Colaptes cafer* characters. (The flickers inhabiting the Cariboo Parklands to the south are *Colaptes cafer*, some apparently of pure strain, others showing slight admixture of *Colaptes auratus* characters.)

The following summarizes *auratus* and *cafer* characters readily observable, in five specimens from Nulki Lake.

No. 1. Adult male, May 9; throat vinaceous-colored, nuchal bar and malar strip red, vinaceous wash on underparts; seven tail feathers are orange-red and three are yellow.

No. 2. Adult female, mated to No. 1, May 9; throat grey, nuchal bar, slight yellow wash on under parts, tail orange-red.

No. 3. Adult female, July 2; throat vinaceous, nuchal bar absent, vinaceous wash on under parts, tail feathers yellow with orange-red shafts.

No. 4. Male, moulting from juvenile plumage, July 23; throat mixed vinaceous and grey, nuchal bar, malar stripe mixed black and red, tail yellow.

No. 5. Female molting from juvenile plumage, July 23; throat vinaceous, nuchal bar, malar stripe black, tail yellow.

Hylatomus pileatus (Linnaeus), Pileated Woodpecker.—Both in 1945 and 1946 a pileated woodpecker frequented a portion of the Sinkut Creek bottom in which was a group of tall cottonwoods. Very likely it nested high up in one of these trees. Another, or perhaps the same bird, was seen several times in flight over the low trees in the bottom, and on two occasions one was heard in the lodgepole pine woods on Sinkut Mountain.

Spyraphicus varius Linnaeus, Yellow-bellied Sapsucker.—One record, viz., an adult male taken by Spreadborough on August 4, 1919. This specimen is in the Canadian National Museum collection; it has recently been critically examined by Dr. A. L. Rand and identified as *Sphyraphicus varius varius* (Linnaeus). The specimen constitutes the second record for th occurrence of the subspecies in British Columbia west of the Rocky Mountains, the first being recorded by Swarth from the upper Stikine River in June, 1919 (Swarth 1922).

Spyraphicus ruber (Gmelin), Red-breasted Sapsucker.—In 1945 this was one of the common nesting birds in the Lakes District; indeed, except on Graham Island in 1920, I have not found it so plentiful elsewhere. The first was observed May 2; later every aspen wood contained a population, one pair to every five acres of this habitat would be a conservative estimate.

During the first three weeks or so of May it was common to see them courting, a male following a female in a spiral ascent of an aspen, or close behind her in short flights through the woods. Sometimes two males followed one female, and it was not unusual to see four or five active individuals within the compass of several hundred square yards. A pair was observed courting so late as July 16.

No special effort was made to locate nests but in the course of the summer five came under observation. All were in live aspens averaging 10 inches in basal diameter. The distances of the nest entrances above ground, in the following account, are approximate.

No. 1. June 7; nest-entrance 40 feet above ground; both parents seen carrying food to young and removing faecal sacs from nest.

No. 2 June 14; nest-entrance 30 feet above ground in one of several live trees standing in an old burn. One parent flew to the tree and, clinging to the trunk below the nest-entrance, apparently passed food to the other; a moment later the first flew from the tree, the second dropped out of sight into the nest.

No. 3 June 29; nest-entrance 20 feet above ground in an aspen growing amongst lodgepole pines; both parents seen carrying food to young.

No. 4. July 1; nest-entrance 20 feet above ground; both parents feeding young.

No. 5. July 2; nest-entrance 20 feet above ground; the young heard crying.

Although the red-breasted sapsucker was one of the commoner nesting birds, as has been stated, the number of young raised seemed inconsiderable, and not until July 19 was the first recorded out of the nest. On this date three, each represnting a different brood, were observed. In all only seven out of the nest were recorded up to August 28.

Several times during the summer an adult was watched as it climbed over prostrate tree trunks and hopped along the ground in search of ants. This food seemed to be the chief item of diet; the stomach of an adult, taken May 9, contained ants exclusively; the stomach of a juvenile, taken July 23, contained ants, and a few seeds of black twin-berry.

In 1946 it was much less common. A pair nested 30 feet above ground in

a tall aspen close to the Vanderhoof road and one parent was observed entering the nest on June 14. This nest had been excavated about one foot above, and a few inches to one side, of a nest that had been occupied in 1945.

On August 8, 9, young birds, probably on migration, were fairly numerous; following that date none was seen until August 26, when a single bird was recorded.

Dendrocopus villosus (Linnaeus), Hairy Woodpecker—Not recorded during spring nor in the nesting season in early summer. Three juveniles that were seen later, viz., July 19, July 23, July 29, and one adult male, September 1, may have come from the neighboring hills.

The stomach of a juvenile male with red crown-patch, taken July 19, contained the seeds of black twin-berries. The subspecies represented is *Dendrocopus villosus monticola* Anthony.

A clutch of four eggs was collected at Fort St. James, May 25, 1889 (Mair and MacFarlane 1908).

Dendrocopus pubescens (Linnaeus), Downy Woodpecker.—Not common. Adults were seen, in aspen trees and willow thickets, on May 9, May 20, May 23 and June 14; two juveniles were observed in a willow thicket on July 19.

The subspecies represented is *Dendrocopus pubescens leucurus* (Hartlaub).

Picoides arcticus (Swainson), Arctic Three-toed Woodpecker.—Not seen by me. Reported nesting at Fort St. James, June 24, 1889 (Mair and MacFarlane 1908).

Picoides tridactylus Linnaeus, American Three-toed Woodpecker.—One record: an adult male, Sinkut Mountain, Vanderhoof region, June 28, 1946. This species was not recorded in 1945.

The subspecies represented is *Picoides tridactylus fasciatus* Baird.

Tyrannus tyrannus (Linnaeus), Eastern Kingbird.—One was recorded on June 6, another on June 12. None seen subsequently until July 8, when two appeared. From that date until August 28 a total of 16 was observed in the Lakes District and at Vanderhoof. Four together, July 30, might have been a family group, and one observed at close range, August 25, was certainly a juvenile. However, definite evidence of any nesting in 1945 was not obtained.

None was seen in 1946 until, on June 22, two appeared in localities that were visited by me regularly—these were thought to have arrived on that day. None was observed subsequently until the autumn migration when a total of seven was recorded as follows: Nulki Lake, August 9—1, August 14—3; Vanderhoof Village, August 15—3.

Mr. and Mrs. Collins informed me that a pair nested on their property at Nulki Lake in 1944 and in several earlier years.

Sayornis sayi (Bonaparte), Say Phoebe.—On August 22, 1945, a bird of the year was observed on a roadside fence near Nulki Lake; the same day a

year later another was seen in almost precisely the same place, and a third was noted near Sinkut Lake. These are the only records.

Empidonax traillii (Audubon), Alder Flycatcher.—Common in the thickets of the bottom lands, the first arrival noted on May 24. All of the local population had left by August 10 and no south-bound transients were seen until August 21. The last was recorded on August 30.

A nest of fine grass, built four feet above ground in a dogwood near the edge of a willow thicket, contained one egg on July 3, two eggs on July 4 and three eggs on July 5. Two eggs hatched on July 18, the third on July 19.

Another nest of the same material plus a small amount of willow cotton, was found in the same willow swamp. Like the first it was four feet above ground in a dogwood. One egg was laid each day from July 8 to July 10; these hatched on July 24 and 25.

A third nest, similarly constructed of fine grass and willow cotton, was woven to the main stalk of a cow-parsnip and completely concealed by the broad leaves. Apparently the nest contained no eggs on July 6, when it was cut down unintentionally by a farmer engaged in scything weeds.

In 1946 it was equally common, perhaps more so. On June 11, in the willow thickets along Sinkut Creek, the characteristic call was heard constantly. During the last two weeks of June the birds generally were silent.

The subspecies represented is *Empidonax traillii traillii* (Audubon).

Empidonax hammondii (Xanthus), Hammond Flycatcher.—This flycatcher seems to be restricted in summer to the lodgepole pine woods on Sinkut Mountain. One was taken there on June 19, 1946, and in 1945 the species was identified satisfactorily on three occasions, viz., May 16, May 23 and September 1.

Five nests containing eggs were found in the vicinity of Fort St. James between June 4 and June 22, 1889 (Mair and MacFarlane 1908).

Empidonax wrightii Baird, Wright Flycatcher.—Much less common than the alder flycatcher; transients observed first on May 16, again on May 17, May 23, and, on the autumn migration, on August 31.

A nest composed of willow cotton, fine twigs, leaf fragments and shredded bark, and lined with fine grass, was situated six feet above ground in a partially dead willow shaded by tall aspens. It contained four newly-hatched young on June 14. The female slipped off the nest, as I stood beneath it, and was not seen again; the male called continually from the nearby aspens. On June 21 it was noted that the young were large and filled the nest completely. The subsequent history of the brood was not followed.

Contopus richardsonii Swainson, Western Wood Pewee.—Not common; recorded first on May 19, last on September 1. Several times during the summer evidence that pairs had nested became apparent, as on June 21 when an adult flew from one perch to another in a group of aspens and whistled continually; also on July 17 when one was seen feeding a full-grown juvenile.

On August 18 a juvenile flew against the window of our cabin, then dropped on a ledge below where it remained long enough to make identification certain.

Nuttallornis borealis (Swainson), Olive-sided Flycatcher.—Recorded three times, and by voice only, as follows: June 24, 1945, June 9, 1946, in a burn four to five miles south of Nulki Lake, and on July 10 in lodgepole pine forest adjacent to Cluculz Lake.

Eremophila alpestris (Linnaeus), Horned Lark.—Horned larks were seen daily, May 3 to 8, in fields of oat stubble and summer fallow close to Nulki Lake. The largest flock noted, on May 6, was composed of approximately 200 birds. Many times the flock was flushed by hunting marsh hawks; the horned larks would circle a few times, their white underparts shining in the sun, then alight again on another part of the field. On August 28 a flock numbering 50± was observed on the same field; by September 3 the number had increased to 200±. Several times a small flock, passing along the lake shore in characteristic undulating flight, dropped down to an inshore 'island' of water-smartweed as if to alight—but none did so.

The stomachs of two birds collected May 6 were filled with oat-fragments and seeds of bindweed *Polygonum convolvulus*. These, as well as all others identified at close range through binoculars, were *Eremophila alpestris articola* Oberholser.

Tachycineta thalassina (Swainson), Violet-green Swallow.—On May 5 approximately 15 were observed flying about over Bradley's Slough. These were transients, and none was recorded subsequently.

Iridoprocne bicolor (Vieillot), Tree Swallow.—Tree swallows, observed May 1, the day of my arrival, were numerous during the spring migration; 50± were counted at Manson's Slough, May 4, and 20 at Bradley's Slough, May 5. Ten or more pairs occupied bird houses placed in aspens close to the shore of Nulki Lake on the Collins' property, and other nesting pairs were noted at several places. One of these nested in an old red-breasted sapsucker hole four feet above an occupied nest of that species.

The local population left about the middle of July; apparently few young were raised—Mr. Collins saw no young birds in the colony on his property, and I saw none elsewhere. On August 18 a small number of transients accompanied migrating barn swallows, and two were recorded on August 28.

Riparia riparia (Linnaeus), Bank Swallow.—On May 29 several were seen in company with rough-winged swallows that kept flying about an eroded clay bank by the Nechaco River at Vanderhoof. Later one, or both, species nested there.

At Sinkut Creek three nesting colonies are established in low, clay banks which are subject to constant erosion by the rapid stream. On June 11, 1945, the largest colony consisted of 118 burrows; by June 20 an additional 18 burrows had been excavated (Fig. 33).

Probably only a small fraction of the 136 holes were in use; actually, on

June 20, only 10 birds were seen entering or leaving. Circumstances did not permit regular visits to the colony so that its history was not recorded. On my last visit there, August 2, the nests were deserted. No young were seen anywhere in the vicinity and the possibility of the young being destroyed by *Protocalliphora* maggots seemed indicated.

In 1946 the bank containing the largest colony had partly broken down since the previous summer. In the remaining portion 90 burrows, not all occupied, were counted on June 9. Numerous bank swallows circled above it, a few occasionally swooping down to enter a burrow; one carrying a small twig was pursued by two other bank swallows. Two six-foot banks were occupied by smaller colonies, one of 10, the other of 12, burrows. Here on June 16 approximately 12 pairs were seen entering burrows, or engaged in making new ones. At times some circled about in pursuit of insects, flying high above the bank, then dashing downwards to the creek and flying along its surface for a few yards. With them were five or six tree swallows.

No large autumn concentration of this swallow, or any other, was observed. The first and only record of transient bank swallows was made on September 1, 1945, when 10 were seen, in company with barn swallows and cliff swallows, on telegraph wires in Vanderhoof village.

Stelgidopteryx ruficollis (Vieillot), Rough-winged Swallows. — Rough-winged swallows were first identified with certainty on May 21 when two, obviously transients, flew about our cabin at Nulki Lake. Later this species was seen numerous times, usually in company with bank swallows. In 1945 a small colony, five or six pairs, nested in a low clay bank by Sinkut Creek, about one-quarter mile from the bank occupied by bank swallows. None was seen there in 1946. A larger number probably nested in a high bank on the Nechaco River, as has been stated, but it was not definitely established, at any place, that both species nested in the same bank.

Hirundo rustica (Linnaeus), Barn Swallow.—This swallow is not common in the Lakes District. It was first observed in the evening of May 22 at Nulki Lake when at least two circled about in campany with 30 or more cliff swallows. Barn swallows were seen only occasionally during the spring migration and few nested locally. One nest, built on a scantling which supported the roof boarding of a hen-house, contained three eggs on June 24 and four eggs on June 25; these hatched July 11. It was noted on July 31 that the four young were out of the nest but, on that day and the day following, they remained inside the hen-house.

About August 2 this pair (or perhaps another) began adding hen feathers to the lining of the old nest and later laid three eggs that were successfully incubated. The male disappeared early in September; the female was found dead at about the time the young left the nest, on or about September 8. The young remained about the farm buildings for another week; following a cold night, September 15, approximately, one was found dead; the others left

that day or shortly after. The information relating to this second brood was supplied by Mr. George Evans.

Young on migration were recorded with tree swallows, August 18, and with cliff swallows and bank swallows on September 1. In both instances not more than five or six were observed.

In 1946 a pair that nested in a poultry-house commenced nest-building on June 11; the nest was completed by June 19 and it held four eggs on June 27.

The first indication of a southern migration was noted August 7 when 32 in one band were counted on telephone wires in Vanderhoof village.

Petrochelidon pyrrhonota (Vieillot), Cliff Swallow. — Probably the most abundant of the swallows nesting in the region; first observed May 5 when about 50 were seen circling about, and through, an old barn at Nulki Lake. Later this building was occupied by a nesting colony and I visited it with some regularity.

On May 18, in the evening dusk, one hundred or more cliff swallows performed what probably was a courtship-flight. Flying very close together they wheeled about within a small compass all chattering excitedly. Not all these remained in the vicinity and the numbers visiting the barn during May and early June appeared to change from day to day and never exceeded 40. By June 5 eight nests were built, against the long rafters which supported the shake roof. The birds then left and were gone until June 12, when the same number, about 40, returned. In the evening they were seen in courtship-flight and flying in and out of the barn. On June 17 it was observed that 15 nests had been completed, so far as could be told from below, and two were in process of construction. On June 29 a total of 39 nests was counted. Although this barn was visited almost daily thereafter, and parents were often seen entering nests, I could obtain no evidence that any young were raised to the flying stage. One nest that fell to the ground had contained three nestlings. These were dead and dried up when found. Possibly they had been killed by the fall, but possibly also they were the victims of fly maggots. On July 31 it was observed that the colony had left; at no time were any flying young seen in the vicinity.

Other colonies in the district had built nests in these situations, viz., under a bridge over the Nechaco River at Vanderhoof, where on May 15 thirty or more gathered mud from the river side; on the stringers of a bridge over Stony Creek; in an old stable at Corkscrew Creek, and in a hay barn near Sinkut Creek. In addition many old buildings in the neighborhood were occupied by small colonies; nests were observed also in several high cut-banks along the Stuart River; these were in small crevices or on narrow ledges.

No cliff swallows were recorded during August; the first autumn transients, 12, were observed on September 1.

The colony, which consisted of 39 nests on June 29, 1945, contained only 19 nests on June 23, 1946; other smaller colonies were proportionately reduced. This reduction may have been a result of *Protocalliphora* infestation in 1945.

Perisoreus canadensis (Linnaeus), Canada Jay.—Seen twice only in 1945, viz., one in the lowlands near Nulki Lake, May 8, and two on Sinkut Mountain, August 8. In 1946 it was common in the last locality. Young in first-plumage were observed there on June 28, and later on, adults, as well as young birds in various stages of molt, frequently came under observation.

These are of the subspecies *Perisoreus canadensis canadensis* (Linnaeus).

Cyanocitta stelleri (Gmelin), Stellar Jay.—Said to be an occasional winter visitant in the Lakes District; one was seen in Vanderhoof village, May 6, 1945, by Mr. Phil Brown.

Pica pica (Linnaeus), Blackbilled Magpie.—At Nulki Lake two magpies were seen on each of the following dates: October 17, 1945, November 5, 1945, December 26, 1945, February 26, 1946 (Lakes District School records).

Corvus corax Linnaeus, American Raven.—Apparently a winter visitant only; two persons told me of seeing ravens feeding on moose carcasses.

Corvus brachyrhynchos Brehm, American Crow.—Common on migration, less so in summer, and, according to several reliable reports, wintering regularly in small numbers about the Indian village of Stony Creek. Another report refers to a large flock, at least 100, wintering near Vanderhoof in 1943-44, and subsisting largely on refuse from a slaughter-house.

It is of interest to note that a banded crow released, by the Washington State Game Department, at Seattle, Washington, on March 3, 1935, was shot at Vanderhoof on April 25, 1936.

During the first week of May a flock of 20± frequented Bradley's Slough where they fed on the carcass of a horse; this animal broke through the ice and drowned during the previous winter. Flocks of similar proportions also were recorded elsewhere in the Lakes District at this time.

The population as noted in early summer was not large and apparently not all of its members nested. In the nesting season it was common to see small flocks feeding together in the fields, and single birds foraging on the lake shores. One nest was situated 15 feet above ground in a thirty-foot alder that overhung the water at Middle Bay. Others were in Engelmann spruce thickets in the Sinkut Creek bottom.

On June 11 a flock of 22 walking over a field recently sown to oats undoubtedly were taking some of the exposed seed. A field of oat stubble, and a summer fallow, at Nulki Lake also attracted small flocks. Crows seldom were seen in the fields surrounding Manson's Slough, a nesting ground for blue-winged teal and other pond ducks, and it was not suspected that a relatively large number of ducks' nests were being destroyed. Details of crow-predation are included elsewhere in this paper.

It was observed on July 10 that crows had become more numerous, more conspicuous, and more noisy, on the lake shores and on open fields. In the evening of July 19 a flock of 90± flew over Bradley's Slough, a place where none had been in evidence since May. From July 25 to August 8, and again,

from August 16 to the time of my departure on September 4, flocks of transients, up to 20, visited the fields near our cabin. The attraction there was waste oats, shelled out on the ground during the previous autumn's harvest. However, as much food had been consumed earlier by crows and other birds, the flocks did not remain long and no concentration took place. Few grasshoppers were available as food, either on these fields or elsewhere.

Nucifraga columbiana (Wilson), Clark Nutcracker.—Reported from Sinkut Mountain by several persons; none was seen when I visited the summit of that mountain on August 19, 1945. Nevertheless the records doubtless are correct. One was collected at Fort St. James, May 13, 1889 (Mair and MacFarlane 1908).

Parus atricapillus Linnaeus, Black-capped Chickadee. — Plentiful in the mixed Engelmann spruce and aspen woods, and in aspen groves amongst the lodgepole pine forests on higher levels. An empty nest, thought to be that of a black-capped chickadee, was examined in late August. It was made of willow cotton and some rabbit fur, lining a small cavity near the top of a five-foot aspen. On and after July 16 troups of young, and adults in full molt, frequently were observed.

A nest and four eggs was collected at Fort St. James, June 4, 1889 (Mair and MacFarlane 1908).

Parus gambeli Ridgway, Mountain Chickadee. — Several small family groups were found, and specimens collected, on Sinkut Mountain, June 23, 1946.

Parus hudsonicus Forster, Hudsonian Chickadee.—On August 18, 1946, a juvenile was collected in lodgepole pine woods at the 3000 foot level on Sinkut Mountain. This was the only one seen. None was recorded in 1945 although each of many spruce stands, their common habitat elsewhere, was thoroughly searched.

Sitta canadensis Linnaeus, Red-breasted Nuthatch.—More or less common in all types of forest visited.

Cinclus mexicanus Swainson, Dipper.—One record only, of a single bird on Nithi Creek, May 7.

Telmatodytes palustris (Wilson), Long-billed Marsh Wren.—The long-billed marsh wren was found nesting at the west end of Tachick Lake; it was not recorded elsewhere. Eight nests were examined on July 8, and wrens were seen, or heard singing, at distances of 20 feet and less.

Each of three nests, close together in a round-stem bulrush marsh and four to five feet above water, was made of bulrush and strips of cattail; all were lined with cattail down. Another group of three, in a mixed cattail and round-stem bulrush marsh, was made chiefly of cattail fibers and cattail down, the last prominent on the outside of the nest. Two were lined with cattail down; one was unlined. None of the eight nests contained eggs. A nest of

cattail fibers and cattail down, collected on August 9, 1946, was attached to a 10 foot fruiting stem of a cattail just below the spadix.

This constitutes the most northerly record for the species in British Columbia. The one specimen taken is representative of the race *Telmatodytes palustris plesius* (Oberholser).

Turdus migratorius Linnaeus, American Robin.—Small flocks of robins passed through the Lakes District between May 4 and May 6; on May 16 it was observed that all the remaining birds at Nulki Lake were in pairs. Of the nests listed below (Nos. 1 to 5 in 1945, Nos. 6 to 11 in 1946) several were examined once only. Others were kept under observation until the young left. With one exception all were of the usual mud-enforced type.

No. 1. Four feet above ground in dead willow; female incubating four eggs, May 30.

No. 2. Six feet above ground in a service berry bush growing amongst aspens close to the shore of Nulki Lake; female incubating four eggs, June 12.

No. 3. Six feet above ground on rafter in open side of barn; female incubating four eggs, July 4.

No. 4. Five feet from ground in willow; female incubating four eggs, July 5. Eggs hatched July 19.

No. 5. Three feet above ground in willow, and sheltered by thick surrounding growth of black twin-berry, at edge of aspen grove; female incubating three eggs, July 8. The adults defended the nest with more than the usual vigor, flying at my head whenever I approached, both before and after the young hatched. On July 16 one parent was seen carrying a soopolallie berry to the young. On July 25 the nest was empty.

No. 6. Four feet above ground in an old willow. On June 8 it contained one young about a week old, and a single runt egg, apparently addled. The nest was empty on June 17.

No. 7. On a horizontal scantling in a granary. On June 17 it contained three eggs. The nest was empty on June 27.

No. 8. On lower branch of a small thickly-foliaged spruce. On June 22 it contained three fresh eggs, one of which was broken; the nest appeared to be deserted. The eggs were taken, probably by a crow, on June 24.

No. 9. A nest without mud in its construction built in a deep cavity in an aspen stump. This nest had been occupied; it was empty on June 22.

No. 10. On top of an aspen stump which was well concealed by willow shoots. It had been occupied and was empty on June 22.

No. 11. Eight feet above ground in a small cottonwood standing in a corral. It contained three fledglings on June 23 and was empty on June 25.

Young robins, usually more conspicuous than the young of other birds when first they leave the nest, were extremely scarce in 1945 and the first was not recorded until July 20. This was a single bird attended by an adult female. Only two others, each attended by a parent, were seen during the remainder of July. On August 7 two females, each with two small young, and on August 9 a female with one young about one-third grown, were observed. Thus eight young was the total seen during the summer. It might be concluded therefore that few, if any, of the first, or the second, attempts at nesting were successful.

Three adults flying from tree top to tree top in an aspen forest on August

16 were considered to be the first autumn transients. On August 20 a migratory movement became more apparent, with 20± recorded in the fields and in the brush along Nulki Lake. Later larger numbers began to appear, for example 50±, August 29. The migration was still in progress when I left the Lakes District on September 4.

Numerous times in 1946 robins were found feeding along the muddy shores, and the exposed bottom, of Bradley's Slough; for example, five adults on June 10. Later in the month full-grown young foraged there.

In 1946 the autumn migration followed much the same pattern; three, thought to be transients, were recorded August 8, but none subsequently until August 14 when, alongside the road to Vanderhoof, small lots, totalling 12, were counted. None was seen on the same territory the following day. On August 18 a migration of adults and young, the last in the majority, was passing through the lodgepole pine woods on Sinkut Mountain.

The local population is identified as *Turdus migratorius migratorius* Linnaeus.

Ixoreus naevius (Gmelin), Varied Thrush.—Recorded twice only, viz., on May 6 when a female was observed at the top of a dead aspen, and on May 8 when one was heard in the deep woods near Bradley's Slough.

Hylocichla guttata Pallas, Hermit Thrush.—Common in the aspen-Engelmann spruce association of the lowlands, and in the lodgepole pine forest on Sinkut Mountain. The first was recorded May 5; by May 15 the species had become numerous and the song was heard constantly; on May 21 a number associated in pairs. Song was continual through June, less often heard during the first two weeks of July and last recorded on July 19.

A nest, containing three eggs when discovered on July 8, was built on the ground in an open growth of low service berry, close to a faintly-marked trail through wide-spaced aspen and spruce woods; leaves of arnica partly concealed it. Dry grass, leaves and weed-stalks formed the substance of its outer structure; the lining was fine grass exclusively. The parent flushed at a distance of a few feet each of several times the nest was passed, and glanced at in passing, during the following ten days; on July 20 the nest was found to be deserted; later two of the three eggs were taken by some animal. A young bird molting from the juvenile plumage, collected July 31, was the only evidence obtained that any of the many nestings had been successful.

During the first week in July the local population moved out and no hermit thrushes were seen until August 26 when two young birds were found dead on a road. It was considered that these represented members of a different population on migration. On August 28 and 29 the first of another wave appeared, chiefly young in first-winter plumage.

Specimens collected at Nulki Lake have been identified by Dr. Alden H. Miller as the subspecies *Hylocichla guttata guttata* Pallas.

Hylocichla ustulata Nuttall, Swainson Thrush.—Common, nesting to some extent in the same habitat occupied by the hermit thrush, but more commonly in the willow and alder thickets; during the summer the

songs of the two species were heard in about equal volume. The local population left early in August, the last individual being identified on August 7. Two waves of migration, composed principally of young in juvenile and first-winter plumage, followed—one August 14 to 19, approximately, the other August 22 to 31.

A juvenile of the local population, the only one recorded, was caught in a mouse trap, July 27. This bird had been feeding on black twin-berries. Another, a transient, taken August 22, had eaten service berries.

The subspecies is *Hylocichla ustulata almoe* Oberholser.

Sialia currucoides (Bechstein), Mountain Bluebird. — Decidedly scarce. Four transients recorded on May 2, two on May 9, represent the total spring migration as observed at Nulki Lake. Later two nests were examined, May 30, June 24. The first was a red-breasted sapsucker excavation in a tall, partly-dead aspen on an open hill-slope, the entrance 35 to 40 feet above ground. The second, built in a hole under the eaves of a cabin, contained young on June 27. A pair examining a nest box at the local school, June 4, and a pair at North Bay, June 6, neither of which were seen again, complete the total of observations for the summer. None was seen in July and none subsequently until August 28 when two transients appeared.

Records kept at the Lakes District School give October 30 as the last date mountain bluebirds were seen in 1945, and March 21 as the date of first appearance in 1946.

In 1946 it was again locally uncommon; four young were seen at North Bay, July 3, and four transients were counted on August 15.

Further to the north, along the Nechaco River, it was more common. Thus on the highway, about 20 miles west of Vanderhoof, a flock of 40± was recorded on August 5. The birds rose from the ground and alighted on telephone wires as a car passed on the road. These were feeding upon grasshoppers.

Myadestes townsendi (Audubon), Townsend Solitaire.—Observed twice in 1945, viz., one heard singing, June 21, in lodgepole pine woods close to a high cut-bank along upper Sinkut Creek, and one heard singing, June 28, beside a cut-bank on Stuart River.

On Sinkut Mountain, June 23, 1946, two young, probably just out of the nest, were collected; both had been parasitized by *Protocalliphora*, as was stated earlier. On August 11 three others were observed near the same place, one being a young bird nearly fully molted to first-winter plumage.

Regulus satrapa Lichenstein, Golden-crowned Kinglet.—Observed first on May 11, and subsequently throughout the summer, the preferred habitat being the stands of Engelmann spruce within the aspen woods. On August 19 it was noted as common in association with ruby-crowned kinglets along a trail through lodgepole pines on Sinkut Mountain.

Regulus calendula (Linnaeus), Ruby-crowned Kinglet.—Abundant on mi-

gration May 2 to 17, usually in company with Audubon warblers and Wilson warblers. These transient ruby-crowned kinglets sang constantly, as did a nesting population—until mid-June. It was noted after June 21 that nesting males sang less often and with less volume and by July 16 had ceased altogether. Transients in August sang occasionally. A south-bound migration was observed first August 16 and 17; it continued in varying degrees of abundance and reached a peak between August 29 and September 3.

Migrations of considerable volume, August 7, August 14, 1946, appeared to consist largely of young molting to first-winter plumage.

Anthus spinoletta Bonaparte, American Pipit.—Abundant transient. In spring flocks of 50 to 60 were seen regularly, May 3 to 19; the last record is for five individuals, May 21. In late summer the first were observed August 26; thereafter they were seen frequently, the largest number recorded in one day being 100±, September 2. Two individuals, the first of the 1946 autumn migration, were seen at Bradley's Slough on August 24.

Bombycilla garrulus (Linnaeus), Bohemian Waxwing.—Bohemian waxwings seen during the summer probably were nesting but this was not verified. On June 22 one of a pair, moving about among shrubbery in a clearing in a spruce forest, carried a large piece of willow cotton in its bill. Obviously this was nest material, but the hope that the bird might be traced to its nest was not realized for suddenly both flew into the woods, so quickly and so far, their course could not be followed.

At Bradley's Slough on June 9 and again on June 20, a pair was seen hawking for insects, dipping and wheeling in the manner of swallows. Numerous times the birds passed overhead, so close that the cinnamon-colored under-tail coverts could plainly be seen. On the second occasion they were fighting a stiff breeze, flying into it for 100 yards or so, then turning, to speed down wind, to turn again and once more labor into the wind. Once both alighted on fence posts close to where I sat, rested a few moments, then resumed their hawking.

Bombycilla cedrorum (Linnaeus), Cedar Waxwing.—The cedar waxwing was the last of the summer visitants to arrive, viz., June 21, 1945—4; June 26, 1946—5. Later, in both years, it became relatively common. The following counts were made in 1945: July 4—16, July 25—5, August 6—1. On August 16, 1946, at least 40 flushed from a saskatoon thicket in a wood of wide-spaced aspens; the bushes were heavy with berries and the waxwings had been feeding upon them. Many of the birds were young molting from juvenile plumage.

A nest of grass and willow cotton, lined with tree moss, was securely fastened, five feet above ground, to two upright branches in a bushy willow. It contained five eggs on July 16, 1945; on July 23 five young filled the interior and by July 25 the young bulged over the rim. The subsequent history of the nest was not followed.

Lanius excubitor Linnaeus, Northern Shrike.—At Nulki Lake, February, 1946, one was observed in pursuit of a red-winged blackbird (Lakes District School record).

Vireo solitarius (Wilson), Solitary Vireo. — One was taken on Sinkut Mountain, June 19, 1946; others were heard in the same locality on June 23. The subspecies is *Vireo solitarius cassinii* Xanthus.

Vireo olivaceus (Linnaeus), Red-eyed Vireo.—Recorded twice in 1945, on the basis of voice only, on June 1 and on September 2. On June 17, 1946, two were heard and seen near Sinkut Lake, both in the tops of tall aspens and cottonwoods.

Vireo gilvus (Vieillot), Warbling Vireo.—First seen May 25, again on May 30. Not common either on the spring migration or in summer, but conspicuously so during the autumn migration of young that commenced on August 14 approximately and was still in progress on September 3.

In 1946 it was relatively common; in June males were heard singing daily, the most favored habitats being small islands of aspens in the lodgepole pine woods, and in willow thickets. A migration of young passed between August 16 and August 19. The subspecies is *Vireo gilvus swainsonii* Baird.

Vermivora peregrina (Wilson), Tennessee Warbler. — This warbler was seen occasionally during the spring migration and in summer; it became more common during the southern migration. The first was recorded on May 18. Undoubtedly a few pairs nested; on June 14 a male sang continually from the tops of aspens growing at the edge of a small swamp, but exhaustive search failed to reveal the nest. On June 27 at least two adult males, under close scrutiny, acted as though feeding young. None was recorded from June 30 until August 15 when the first autumn transients, all young in first-winter plumage, appeared. Eight were counted in about one acre of willow swamp, August 16, and thereafter a few were seen at intervals until August 27. In 1946 a migration of young in first-winter plumage was recorded between August 7 and August 16.

Noted as more common in 1946. Males sang freely in the aspens up to about June 14; later the song was heard less frequently, the last date recorded being July 4. On June 11, as I walked along an unused and grass-covered trail through aspen woods in the Sinkut Creek Valley, a male, invisible amongst the top foliage of an aspen, sang persistently. After some hunting in the vicinity a female was flushed from a nest containing six eggs. The nest, made entirely of fine grass, filled the entrance of, and was roofed over by, a short tunnel at the base of a single-stemmed willow that stood beside the trail.

Vermivora celata (Say), Orange-crowned Warbler.—Recorded first on May 8, when at least three were seen. Thereafter a few appeared occasionally, in the new leafage on the aspen tops, and in willow swamps, until May 18. None observed in summer. The first autumn transients (two) were seen on August 22; others were recorded on August 31 and September 2. On August

25 a male in first-winter plumage, of the subspecies *V. c. orestera* Oberholser, was collected.

Dendroica petechia Linnaeus, Yellow Warbler. — Seen first on May 22, again on May 24 and May 29. By June 1 it was common, the males singing continually from willow tops in the swamps and in certain aspen clumps. A nest, four feet above ground in a service berry bush growing at the edge of an aspen bluff, was composed of fine grass, weed-stalks and plant-fiber, with a lining of horsehair; a few white feathers from a domestic fowl had been added to the exterior and to the lining. It contained three eggs on June 15 and five eggs on June 17. The eggs were hatched on June 27 and the nest was deserted on July 7. Later it was discovered that one, at least, of the brood had been a host for fly larvae. None was seen from the end of July until August 26; on the last date and again on August 28 the first autumn transients, two young in first-winter plumage, were recorded.

The species was not observed in 1946.

Dendroica magnolia (Wilson), Magnolia Warbler. — Not identified in spring nor during the nesting season. An adult male, July 14, and an adult female, July 20, were taken to be south-bound transients. A young bird in first-winter plumage, August 30, represented the third, and last, record for 1945.

In 1946 an adult male was recorded June 20, 21; three young in first-winter plumage, the first transients, were observed, August 17.

Dendroica coronata (Linnaeus), Myrtle Warbler. — During the spring migration dozens of Audubon warblers were closely scrutinized in search of myrtle warblers, but not until May 12 was one identified. This bird, a male, was alone in lakeshore shrubbery. Another male, positively identified on May 21, was the only other individual recorded. None was identified during the autumn migration.

Dendroica auduboni (Townsend), Audubon Warbler.—The most abundant warbler on migration in spring and in autumn, males first recorded May 1, females May 4. The peak of the spring migration was thought to be between May 8 and May 11; the last transients were recorded, May 22.

The lodgepole pine woods on Sinkut Mountain is the principal nesting ground; pairs were distributed about one-quarter mile apart in this habitat. The first young in juvenile plumage was noted July 19, three others on July 23. A south-bound migration of young first became apparent August 2; it continued in greater or less volume through August and still was observable on September 3. Those first seen were juveniles molting to first-winter plumage; by August 15 all that were scrutinized closely had fully acquired first-winter plumage. None was recognized as an adult. On August 30 the species was in evidence in all types of woodland habitat, particularly so in willow thickets and in brush along the shore of Nulki Lake.

A nest and four eggs collected at Fort St. James, June 1, 1889 (Mair and MacFarlane 1908).

Dendroica townsendi (Townsend), Townsend Warbler.—At Nulki Lake, May 17, a male of this species was examined through binoculars at a distance of approximately 30 feet while it stood on the outer extremity of a spruce twig. This is the only record.

Dendroica striata (Forster), Black-poll Warbler. — On August 27, in a willow swamp near Bradley's Slough, I collected a young male in first-winter plumage, and saw one other. These are the only records.

Seiurus noveboracensis (Gmelin), Water Thrush. — Common summer visitant, first recorded on May 26 when many were seen or heard amongst the brush on the shore of Nulki Lake. On July 16 an adult, presumably a female, observed in the alders beside Bradley's Slough, was much disturbed by my presence there; she fluttered over the ground and repeated a sharp-call note continually. After a search it was discovered that her excitement was due to the presence in a low bush of a fledgling about three-quarters grown. No other members of the brood could be found.

A small migration of juveniles and young in first-winter plumage was recorded between August 2 and August 29. This movement probably reached a peak about August 8; in the evening of that date eight were counted along a quarter-mile of shore on Nulki Lake—in clearings amongst the brush, in flight from one tree to another, and in full view on the open beach.

In 1946 only two were observed, one on June 20, the other on August 15.

A nest with five eggs, June 25, another with four eggs, June 26, 1889, were collected at Fort St. James (Mair and MacFarlane 1908).

Oporornis tolmiei (Townsend), Macgillivray Warbler.—Apparently not common as only five were recorded during two summers, viz., on July 25, July 27, August 30, 1945; August 7, August 16, 1946. All were young of the year.

Geothlypis trichas (Linnaeus), Yellow-throat. — First recorded May 24, when a male was heard singing in the willows at Bradley's Slough. Later it was common in all suitable places, the males conspicuous and fearless on their territories. As with so many other small birds nesting seemed to be largely unsuccessful; only one juvenile was observed during the summer, on August 14. The last adult was seen on August 8. A migration of young in first-winter plumage, noted first on August 22, seemingly reached a peak August 29 to 30 and continued in smaller numbers at least to September 2.

The population of the bottom-lands at Nulki Lake was smaller in 1946. At least two late broods of flying young, being fed by parents, were seen on August 7, and, on the same date, young molting to first-winter plumage were recorded. Another brood, young in juvenile plumage with ensheathed first-winter plumage feathers on neck and flanks, was being fed by the female on August 17.

Wilsonia pusilla (Wilson), Wilson Warbler. — Observed frequently dur-

ing the spring migration, in lake-shore brush and in the aspen tops. The first males (two) were recorded on May 5, and they were considered common on May 18 when 12 were counted; the first females were noted May 18 and became common May 19; the bulk of the migration had passed by May 21. The last records, for two, two, and one individual respectively were May 23, May 24 and June 1. None was seen during the nesting season nor amongst the south-bound warblers migrating in August, 1945. The sole record for 1946 was one individual observed in a willow thicket at Sinkut Lake, August 7.

Setophaga ruticilla (Linnaeus), American Redstart.—The redstart was the most abundant nesting warbler, with territories in most of the aspen stands, in alders and in willow thickets. The first, either a female, or a male of the second year, was noted June 5. An adult male was seen, and heard singing, on June 6, and again on June 11; thereafter redstarts were recorded daily until July 29. It was observed at Bradley's Slough on July 30 that all had left, but on July 31 a small migration of adults was noted in the high alders on the west side of Sinkut Lake. No young had been seen up to that time. The main autumn migration, presumably originating elsewhere, commenced August 7 and continued through that month. Amongst the numerous young in first-winter plumage, that made up the greater part of the transient population, were noted several adults, and several second year males in molt to adult plumage. Two males were heard singing on August 29.

On August 7, 1946, it was observed that few of the summer population remained, only two being recorded on that date. A week later it had become more common; the numbers then fluctuated from day to day as successive waves of transients appeared, then passed on. It was still present, and several males were heard singing, when I last walked through the woods on August 28.

A newly completed nest, four feet above ground in a dogwood, was found on June 29. It was composed of willow cotton and fine grass, lined with fine grass, deer hair and one feather from the ruff of a ruffed grouse. Three eggs had been laid by July 2. When next visited, July 5, the nest was empty.

Passer domesticus (Linnaeus), English Sparrow. — Occasionally seen in Vanderhoof, as on June 24—3, but not on the farms adjacent to the village, nor elsewhere in the district.

Sturnella neglecta Audubon, Western Meadowlark. — One record. On May 4, at South Bay, Nulki Lake, a meadowlark flew up from the grass and alighted on the top of a small willow by the lake shore. I examined this bird through binoculars from a distance of 20 feet. It was not there the following day, nor were others seen later. The meadowlark is unknown to the local residents.

Xanthocephalus xanthocephalus (Bonaparte), Yellow-headed Blackbird.—An adult male on migration was seen May 27 in the marsh at Manson's Slough and small numbers were recorded at Tachick Lake, July 4, July 8, July 12 and August 6; undoubtedly they were breeding at three different

places on this lake for on July 8 a male was seen carrying food in its bill, and one flying young was noted amongst several adult females that flew from one point in a marsh to another. On August 21 an adult male, fully molted, was collected at Sinkut Lake, one of four that accompanied a flock of red-wing blackbirds.

In 1946 it was first observed at Nulki Lake on April 12 (Lakes District School record). Mr. M. Lynum told me that in December, 1945, a single male was seen amongst a flock of Brewer blackbirds and red-wing blackbirds that wintered about the farm buildings.

On a pasture near Sinkut Lake, June 19, a female accompanied five cowbirds and one Brewer blackbird that were following a herd of cattle. An adult male was seen at Tachick Lake, August 9, in the midst of a flock of red-wing blackbirds.

The above constitutes the most northerly records for the species in British Columbia.

Agelaius phoeniceus (Linnaeus), Red-wing Blackbird. — Male red-wing blackbirds were heard whistling close to Vanderhoof on May 1 and at Bradley's Slough on May 4; at the last place nine were counted on May 5. The first females were recorded, at Bradley's Slough, on May 19. Nesting colonies at Bradley's Slough, Manson's Slough and Collins' Marsh were studied; others were noted at Tachick Lake and Stony Creek.

Eight pairs nested at Bradley's Slough, and on June 7 each of the eight nests was examined. One was in process of construction and a female was seen carrying to it a long piece of dry sedge; the others contained eggs in the following numbers: 1/1, 4/4, 2/5. The nests were constructed of dry, flat sedge-leaves with linings of fine, round-stemmed, or flat-stemmed, grass. All were deeply cup-shaped. Each of the eight was situated in a sedge clump, the sides of the nest woven to the new green leaves and well concealed by them, the bottom resting on old growth at the base of the clump. Five were at the water-edge of the shore marsh; three were in isolated clumps, and separated from the edge of the marsh by several feet of open water. At that time the sedges averaged 18 inches in height; the nests were eight to 10 inches above water.

The choice of sedge clumps as nesting sites (the only adequate sites available at Bradley's Slough) requires that nest-building be delayed until the new growth is high enough to afford support. Thus nesting was later there than in other marshes where nesting sites of last year's cattails were used.

Later it was observed that, as nests became heavy with the increased weight of the young, the thin sedges proved to be insecure sites unable to support the nests in a horizontal position. By June 25 the nests and the sedge stems supporting them lay at various angles; one nest had turned over on its side; another was at so steep an incline that the four young might be expected to fall out at any moment. So far as could be learned no young were raised from this first nesting; whether they fell out of the nests and drowned, or

were taken by predators, or were killed by fly maggots, was not established. It may, or may not, be significant that adults in this colony, the males particularly, were more vigorous in defense of nests than red-wing blackbirds usually are—or so it seemed. The males flew down within a few inches of my head, alighted on the sedges within two or three feet of my canoe, poised in the air over my head, and kept up a constant, excited chatter while doing so.

On July 4 it was observed that the population had declined to three pairs and that at least two pairs were re-nesting. On July 11 a nest in the base of a sedge clump, 15 feet inside the marsh, and more securely fastened than others had been, contained three large young. Another pair, seen the same day, was accompanied by two flying young. The adult males were as demonstrative as formerly. When last counted, July 16, this population consisted of five males, three females and one flying young.

A colony of approximately six pairs nested in Manson's Slough. Two nests examined June 6, one with four, the other with five eggs, were built of flat sedge lined with fine, round-stemmed grass. Each was woven securely to the stems of stout sedges, about two feet in height, which afforded secure anchorage and good concealment. On June 27 a brood of three young, about three-quarters grown, was flushed from this marsh.

At least 12 pairs nested in islands of cattails, surrounded by sedges, in Collins' Marsh. Nests were all of the same type, viz., deep baskets of sedge and cattail fibers, lined with fine grass, fastened eight to 14 inches above water in clumps of last year's cattails. Several were situated close to old nests of the previous year. One was four feet, another nine feet, distant from a coot's nest containing eggs. On June 14 reproduction was in all stages from half-finished nests to nests with eggs on the point of hatching. One nest contained a single egg pierced on one side, in which was a dead chick. No young were observed. On July 1 all nests examined were empty; a few small, weak-seeming young were flushed from the marsh. These might have been hosts for fly-maggots; their manner of flight suggested that possibility.

Many of the marshes at Tachick Lake were occupied by nesting pairs but none came under close observation. It was noted on August 6 that a female was carrying food to her young—surely a late date for young to be in the nest.

Although local colonies produced few young, colonies elsewhere evidently had greater success; juveniles were a conspicuous element in the flocks of transients that first appeared on July 22. At intervals, from July 22 to August 15, red-wing blackbirds and Brewer blackbirds, flocking together, visited the fields about Nulki Lake where they foraged for oat kernels amongst the weeds of a summer fallow, and about an old straw-pile. On July 30 the number of red-wing blackbirds exceeded 150; of these approximately 75 per cent were juveniles, 15 per cent adult females and 10 per cent adult males.

Two of four juveniles collected had their gullets filled with oats; the stomachs of the other two contained oats and seeds of bindweed.

In 1946 it was learned that a flock of red-wing blackbirds and Brewer blackbirds had remained about the farm buildings at Nulki Lake the previous

winter. A female red-wing blackbird, found dead in February, was sent to me in the flesh. Two males were seen at Bradley's Slough on June 10, but none nested there; Manson's Slough being dry was not occupied. Three pair were seen in the nearly-dry Collins' Marsh on June 17 but I found only one nest there; this held two eggs. A total of 20± was counted at Tachick Lake on August 9.

The red-wing blackbird of the Vanderhoof Region is identified as *Agelaius phoeniceus arctolegus* Oberholser.

Euphagus carolinus (Muller), Rusty Blackbird.—A summer visitant to the Lakes District, less common than Brewer blackbird. A mated pair observed May 17 and again on May 19 were the first recorded. In the top of a tall aspen beside a willow swamp on May 20 two males courted two females. The courtship consisted of a simple display; the male sidled along the branch to within a foot or so of where a female stood then spread both wings outward and downward, accompanying the movement with a soft, musical whistle. This completed he straightened to a normal position on the branch. Sometimes the female flew to another branch before the display, or she flew immediately afterwards; the male quickly followed. The display, the short pursuits, the display again, continued in the aspen top for several minutes.

Adults were noted occasionally, usually foraging on the lake shore, during the summer. On August 8 one young bird in second plumage visited the beach on Middle Bay and in the evening of August 14 several molting adults and young were seen there. These were evidently on migration, as were others recorded August 25 and August 29.

On June 28, 1946, a pair was observed feeding young beside one of the small lakes on Sinkut Mountain. The male, more than the female, was concerned at my near approach; he flew from the marshy edge of the lake, where he had been foraging, into a nearby aspen, and from there to another tree, giving the sharp alarm note at short intervals.

Euphagus cyanocephalus (Wagler), Brewer Blackbird.—Small flocks were seen in spring walking through the broken-down sedges on the shores of Bradley's Slough, and at other places as well. A small colony nested amongst dead willows in a clearing along Sinkut Creek where, on May 31, adults were noted carrying food in their bills. Another colony nested in the willow swamp near Bradley's Slough and, probably, a third in the vicinity of Stony Creek Village where a flock was seen each time the place was visited. From July 11 until July 30 flocks consisting of adults and young visited the fields about Nulki Lake; sometimes red-wing blackbirds accompanied them. The total of Brewer's blackbirds present in any day was usually close to 100, the largest number estimated at any time being 175 on July 18.

None was recorded from July 31 to August 6; on the last date approximately six were seen. In the evening of August 20 a flock of 100± alighted on the ridge of a barn and in adjacent spruce trees. They stayed only a short

time and did not descend to the ground to feed. On August 29 a flock of similar size passed by, flying high and travelling west. Two days later another flock, somewhat smaller, was recorded at Bradley's Slough. In the latter part of August flocks also were noted in the village of Vanderhoof.

The flocks that visited Nulki Lake in July spread out to feed over the fields and the grasslands; presumably the birds were finding waste oats and weed seeds—very few grasshoppers were available. Sometimes they foraged also along a narrow beach recently exposed by the falling water-level of Nulki Lake. There they fed and moved about close together and, on occasion, it was possible to obtain some idea of the relative numbers of adults and young composing the flocks. Thus on July 16 the number of adult males, in a flock of 175±, exceeded the number of adult females and young combined at a ratio of about two to one. Later in the season, when a greater percentage of females and young might be expected, circumstances did not permit further investigation of the sex ratio.

In 1946 three pairs nested along Sinkut Creek, in the same area occupied by the species in 1945. Adults were seen carrying food to young on June 11; the first flying young was noted on June 18. All had left their territories some time before June 24, and were not seen again in the vicinity. Later in the summer, e.g., August 8, numerous small flocks frequented the outskirts of Vanderhoof. Small numbers remained about farm buildings at Nulki Lake during the winter of 1945-46.

Molothrus ater Boddaert, Cowbird. — Fairly common, first observed on May 11; later several often were seen perched on the backs of grazing horses. During the latter part of May and until June 20 an upright pole beside our cabin served as a perching place for a male. Almost every day for five minutes or longer he whistled from this vantage point. No adults were seen after the end of June; the last juvenile was recorded on July 25.

Two song sparrows' nests, parasitized by cowbirds, came under observation. The first, on June 12, contained four song-sparrow eggs and two cowbirds' eggs. On June 14, 11:45 a.m., it was seen that the two cowbirds's eggs had hatched; all song sparrow eggs were hatched by June 18. By June 20 the cowbirds occupied two-thirds of the nest; on June 22, 6:30 p.m., one song sparrow was missing and the cowbirds all but hid the remaining three. On the following morning both cowbirds and song sparrows were dead, or dying, as a result of *Protocalliphora* infestation. The second nest, discovered June 28, held four song sparrows' eggs and one newly hatched cowbird. The eggs hatched on July 1; in the morning of July 3 one song sparrow was dead in the nest and by the evening of that day it had been removed. By July 5 the young cowbird occupied one-third of the nest; on July 7 all the young were dead from fly-maggot infestation.

It was inferred that a female yellow-throat, observed feeding a young cowbird on July 25, was a foster mother to this bird. This was the only other species noted as parasitized by cowbirds.

Recorded twice during early summer of 1946, the first, a male, on June 17. Four males and a female, accompanied by a Brewer blackbird and a yellow-headed blackbird, were observed June 19 following a herd of cattle pastured near Sinkut Lake. Two juveniles were recordsd on August 14. The subspecies represented is *Molothrus ater artemisiae* Grinnell.

Piranga ludoviciana (Wilson), Western Tanager.—Two spring records, viz., May 19, May 24. Both were males and both sang; no evidence of nesting was obtained. Later records are: an adult male, July 16; young in first-winter plumage, August 17—3; August 27—3; August 29—1.

In 1946 a male and female on June 22, and a female, June 23, were recorded. A migration of young in first-winter plumage was observed in an aspen wood on August 8. These birds were tame and came to peer at me from distances sometimes less than ten feet. A single individual was recorded on August 14.

Hesperiphona vespertina (Cooper), Evening Grosbeak.—A flock of five perched in the tops of several dead willows at Sinkut Creek on August 29 were the only individuals of this species recorded. One, examined through binoculars, was certainly a juvenile; several of the others, less clearly seen, may also have been young. Very likely this group represented a family.

Carpodacus purpureus Gmelin, Purple Finch.—Common summer visitant; an adult male seen and heard singing on May 8 was the first recorded date of appearance. On May 18 one flock of 12 another of 5, evidently transients, were counted. Later, singing males became conspicuous at many places in the aspen woods of the Lakes District and in Vanderhoof village.

On June 6 a nest containing four eggs, on the ground in the center of a dead willow close to the edge of an aspen wood, was examined. The site was unusual; I have been unable to find any reference in literature to this species nesting on the ground. An adult male was flushed from the nest on June 6, and again on June 9 at 6:30 p.m.; neither time was a female seen in the vicinity. On June 18, when the nest was next examined, it held three dead young and one egg containing a large dead embryo. Hundreds of ants fed on the dead birds; the nest was filled, to a depth of about one-half inch, with these insects.

A brood of full-grown young was noted on July 16, feeding on black twinberries; on August 15 the first transients, three at least, were recorded; others were seen August 17 and September 2.

The subspecies is *Carpodacus purpureus purpureus* (Gmelin).

Pinicola enucleator (Linnaeus), Pine Grosbeak.—Residents of the Lakes District are familiar with this species and report its occasional occurrence there in winter.

It was present all winter in 1945-46, the first flock seen November 20,

1945, the last—a flock of four including one red male, on March 1, 1946 (Lakes District School record).

Spinus pinus (Wilson), Pine Siskin.—Common, usually in flocks up to 20; the first recorded, a flock of 15, on May 28. On June 19 a male under observation sang several times from the top of a dead willow. Later siskins became more plentiful; a flock of 35± was observed feeding on dandelion seed on July 5, and during the remainder of my stay in the district flocks were recorded almost every day.

Less common during June, 1946, than it had been in the early summer of 1945, but noted as plentiful August 7, when several small bands of four to six and one flock of 60 to 70 were observed. Siskins were subsequently observed daily until August 15; then they disappeared. Several times they were seen feeding on the seeds of cow-parsnip.

A nest and three eggs was collected at Fort St. James, June 27, 1889 (Mair and MacFarlane 1908).

Loxia curvirostra Linnaeus, Red Crossbill.—Red crossbills first came under observation early in August; it is doubtful if any were present earlier. Some were in pairs others in small flocks numbering as many as eight or 10. Some, possibly new arrivals, were encountered in willow thickets along Sinkut Creek, but the majority had been attracted to the spruce stands which carried a heavy crop of seed. A male collected August 7 was in breeding condition, the testes being three millimeters in length. On August 23 a male sang from the top of a spruce. Crossbills still were being noted up to September 3.

All of several specimens taken are of the race *Loxia curvirostra bendirei* Ridgway.

No crossbills of either species were seen in 1946. There were no new cones on the spruce tree, those of last year still hung in masses, and the crop of lodgepole pine cones was very light. The absence of crossbills might be attributed to the scarcity of this food, but I doubt if that is the correct explanation. In the Cariboo Parklands where the crop of Douglas fir cones was heavy only two crossbills were seen during the time spent there in October.

Loxia leucoptera Gmelin, White-winged Crossbill.—On August 29 and 30 a flock of six, of which at least two were adult males, alighted in dead willow tops standing amongst shrubbery along Sinkut Creek. Dissection of a male and a female showed that both had recently bred.

Passerculus sandwichensis (Gmelin), Savannah Sparrow.—Noted first on May 2, again on May 5, and commonly May 8 to 11. Following the last date the numbers of transients passing through declined, then increased again on May 21. Numerous pairs remained to nest in the Lakes District. On June 17 a female was flushed from her nest and five eggs, well hidden by overhanging stems of old grass. When next examined on June 27 the young were several days old. Another nest, with four eggs, was found, June 24, on a burnt-over knoll. It was on the ground and hidden by a dead, prostrate

aspen that provided perfect cover and concealment. The nest was made of fine grass and lined with a little horsehair.

Amongst the willow thickets near Bradley's Slough on June 27 adults were feeding young, and young out of the nest were recorded on June 29. A migration of considerable volume first noted August 27 was still in progress on September 3.

In 1946 the nesting population at Nulki Lake was definitely smaller, thus on June 10 only two pairs were found on territory occupied the previous year by at least four pairs. On June 13 one was flushed from a nest containing five eggs situated in a patch of mint near Sinkut Creek; on June 19 an adult with a grasshopper in its bill evidently was feeding young in the nest. None was seen between August 6 and August 19; the first autumn transients were recorded on August 20, and by August 25 it was abundant along the roadsides.

Pooecetes gramineus (Gmelin), Vesper Sparrow.—Not recorded until May 13 when two males were seen, and heard singing. These were the first members of a small migration that, noted daily, seemed to reach its peak and its culmination on May 31. None was seen during the first 10 days of June; later it was learned that three pairs had established territories in a belt of grassland and aspen-margin along a quarter-mile shore of Nulki Lake. Males were heard singing as late as July 9. Vesper sparrows were last recorded August 30.

Junco hyemalis (Linnaeus), Slate-colored Junco.—An adult female, with brood-patch, was caught in a mouse trap on the summit of Sinkut Mountain, August 12, 1945. This specimen is typical of the subspecies *Junco hyemalis cismontanus* Dwight.

Junco oreganus (Townsend), Oregon Junco.—Juncos in small numbers, perhaps representing the last of a migration, were observed along the roadsides on May 4. Few pairs remained to breed in the lowlands of the Lakes District; a brood of flying young, in juvenile plumage, accompanied by one parent, recorded July 4, may have been locally bred and very likely a nesting population inhabited the more suitable lodgepole pine-aspen habitat at higher elevations. The first indication of an autumn migration, viz., three bands totalling 20, chiefly young in molt, was recorded August 15. After a few days the number of transients increased and flocks were seen daily—totalling 50 August 20 and 100± August 21. The migration continued through August and was still in progress when the investigation terminated.

In 1946 broods of flying young were noted on June 18, June 27 and July 4. As late as August 7 an adult was attending full-grown young that probably were a second brood. Juncos were seen commonly until August 15 after which only two to four were counted daily. No large invasion had taken place up to August 28.

Juncos, possibly of this species, wintered about farm buildings in 1945-46.

Two nests were collected in 1889 at Fort St. James, one with two eggs on May 16, one with five eggs four weeks later (Mair and MacFarlane 1908).

The subspecies is *Junco oreganus montanus* Ridgway.

Spizella passerinia (Bechstein), Chipping Sparrow. — Common summer visitant, first recorded May 17 when three were seen in open aspen woods, and noted as becoming numerous on May 19. A migration continued until May 31, a few individuals being seen daily in the aspens, on the grasslands, and along the lake margins.

In 1946 several nesting territories that had been occupied in 1945 were vacant and a general survey of the bottomlands suggested that the population was smaller. However, the population nesting in a lodgepole pine habitat on Sinkut Mountain did not seem to have declined in numbers. Five nests were studied:

No. 1. Habitat, grassland and aspen. Nest, three feet from the ground in a black twin-berry, made of fine rootlets and grass and lined with horsehair, contained three eggs on June 14, four eggs on June 15 and five eggs on June 16. One egg was hatched June 25 and the remainder by June 27. On July 5 the young, then not quite half-grown, left the nest for the adjacent aspens where the parents fed them for the next several days.

No. 2. Same habitat as No. 1. Nest, two feet from the ground in a black twin-berry, and constructed of the same materials as the first, contained four eggs on June 28. The following day three eggs were taken by some animal.

No. 3. Habitat a 20-acre slashing with new growth of black twin-berry, willow and a few seedling spruce. Nest of the common type built halfway up a two-foot spruce, contained two half-grown young and two infertile eggs on June 20. When the male parent first was seen, at least 100 yards from the nest, it carried a green caterpillar in its bill. Later both parents remained close to the nest. Both young flutttered from the nest; one was caught and returned, the others could not be found in the thick shrubbery. On June 23 both parents still were on this territory and feeding young out of the nest.

No. 4. Same habitat as No. 3. Nest in a black twin-berry bush contained three naked young and one egg on June 20. One parent was seen close by with a caterpillar in its bill. This nest was empty on July 1.

No. 5. Farmyard and kitchen garden. Nest containing more than the normal amount of horsehair (black) was built four feet above ground amongst thick foliage on the lower branch of an Engelmann spruce, and contained five fledglings on June 25. Two fluttered out when the nest was examined; these were put back but they immediately left the nest again.

Few young were seen in either year and in mid-August the species suddenly became scarce; none was recorded between August 16 and September 2, 1946. No autumn migration was observed in 1946.

The subspecies is *Spizella passerina passerina* (Bechstein).

Spizella pallida (Swainson), Clay-colored Sparrow. — On May 31, in a willow swamp on the Sinkut Meadows, I heard the unmistakable song of a clay-colored sparrow, and, for a moment, saw the singer in flight; this was the only observation that year.

The clay-colored sparrow was a common summer visitant in 1946. It was estimated that at least 10 males were established on territories on approximately 100 acres of bottomland, and on a sloping grassland and aspen association, along Sinkut Creek. The first singing males were noted June 11, the last on June 29.

The most favored area appeared to be a 10-acre tract of slash grown up with shrubbery, chiefly willow and black twin-berry, and bordering a hay meadow. This contained five territories: one territory, on which I watched, and listened to, the male on a number of occasions, was estimated to approximate 150 x 100 yards of brushy ground, bounded on one side by high willows, on another by the meadow, while the other two boundaries were not defined by any physical barrier. Within this territory three dead willows, higher than the surrounding green shrubbery, and one green willow on the periphery of the territory, were used as singing perches—the male moved from one to another, apparently without showing preference for any one of them. Intensive search here, and in other territories where males sang frequently, failed to locate a nest; neither were any females seen in June. It seemed likely that few of the males succeeded in attracting females; possibly because the population was predominantly male. At any rate none identified as a female was seen until August 7 when I collected one. This bird had a functional brood patch and undoubtedly had bred. On the same day I flushed a brood of three or four young but could find none after they had dropped again into the shrubbery. None was seen subsequently until August 24; on this date three transients were observed on the area that in early summer had been occupied by five males.

Zonotrichia leucophrys (Forster), White-crowned Sparrow.—The northern migration of white-crowned sparrows was in progress on May 2; flocks up to 50 constantly came under observation in brush thickets and along roadsides. The species was the commonest land bird recorded on that date and continued to be so until May 9. Two days later it was noted as less abundant, and by May 13 the migration had ceased. During the height of the migration dozens fed daily in an old granary where a little wheat had been stored since the previous winter.

A few pairs nested in the bottom-lands, and males were heard singing there during the latter part of May. On June 27 the behavior of a female indicated she was feeding young, as did that of a pair on July 17. A young bird molting from juvenile plumage was observed August 7.

Approximately 10, all young in first-winter plumage, noted August 23, represented the first of the autumn migration. In the days following the movement increased in volume and still was in progress when the investigation ended on September 5. Probably not more than one per cent of those seen were adults.

In 1946 four pairs, established on territories at widely separated places near Nulki Lake, were seen numerous times from June 16 to June 24. One habitat occupied was open slashing on which numerous shrubs had grown;

another was a piece of rough ground covered witih small aspens; a third, the brushy margin of a cultivated vegetable garden. Territories within these habitats were defended vigorously. A male of one pair was seen driving off a chipping sparrow; another was seen in pursuit of a junco, and each of the three pairs became much excited when I entered its territory.

A nest and four eggs was collected at Fort St. James, June 14, 1889 (Mair and MacFarlane 1908).

The subspecies represented is *Zonotrichia leucophrys gambelii* (Nuttall).

Zonotrichia coronata (Pallas), Golden-crowned Sparrow.—Recorded only once, viz., at Nulki Lake, May 6, when two were identified in a flock of white-crowned sparrows. One of these was collected.

Zonotrichia albicollis (Gmelin), White-throated Sparrow.—In 1945 males were heard singing, in the Sinkut Meadows, on May 30, June 7 and July 18. An autumn migration was observed from August 24 to September 2 and during that period a total of approximately 20 was recorded, young birds molting to first-winter plumage being in the majority. Specimens of both adults and young were taken.

In 1946 the nesting population was very much larger. It was estimated that at least 35 pairs occupied about 150 acres of bottom-land along Sinkut Creek. Here males, less often females, were seen daily. Other pairs were widely scattered through the district.

On June 11 a female was flushed from a nest, containing four eggs, built on the ground at the base of a black twin-berry growing in the center of a small open space amongst dense shrubbery. The nest was made of dry, yellow grass with a lining of fine grass and moose hair (Fig. 34). The eggs were profusely marked with small cinnamon-colored spots.

The nest was visited at short intervals until June 27; on each visit during the incubation period the female was on or close by the nest; when disturbed she would fly about amongst the adjacent shrubs uttering a sharp alarm note. The male was not seen during this period. On June 18 two eggs had hatched; the young, of a deep-orange shade, seemed very conspicuous against the light-colored nest lining. By June 24 the four young were well-grown with sheathed wing feathers—neither parent was observed on this occasion. On June 27 I took one young out of the nest for examination; the others ran out like mice and successfully concealed themselves in thick brush. Both parents were present and chirped excitedly.

Another nest, of fine grass with a lining of moose hair and black horsehair, was discovered on a small open space amongst aspens; it contained three eggs on June 27, and four eggs on June 29 (Fig. 35). These eggs were white sparingly marked with large pinkish-brown spots, quite different from those in the first nest. The female was flushed both times the nest was examined.

It was observed on August 7 that no white-throated sparrows were in their usual haunts; none appeared there until August 24 when a single transient young in first-winter plumage was recorded.

Figs. 32-37: 32. Young rufous hummingbird in nest; 33. Nesting colony of bank swallows, Sinkut Creek; 34. Nest and eggs of white-throated sparrow No. 1; 35. Nest and eggs of white-throated sparrow No. 2; 36. Woodchuck *Marmota monax petrensis*, Nulki Lake; 37. Moose feeding on *Potamogeton* at Bladley's Slough. (Read figs. from left to right beginning at top.)

In British Columbia, west of the Rocky Mountainis, the white-throated sparrow has hitherto been regarded as of rare and casual occurrence. The following are believed to be the only published records: Kispiox Valley, June 21, 1921; Vanderhoof, August 15, 1919; Indian Point Lake, October 7, 1926, Spring 1928 (3 birds banded); Okanagan Landing, September 9, 1931; Saanich, Vancouver Island, October 16, 1931. East of the Rocky Mountains it is known to be a common summer visitant to the Peace River District of British Columbia.

The observations, therefore, of a migration and a nesting population in the Lakes District is of considerable interest. Undoubtedly the migration of 1945 was larger than is indicated by the 20± birds observed, for that number could have represented only a fraction of the number passing through. As only a few (five to be precise) have been reported from places south of Vanderhoof it seems reasonable to assume that the migration through that region was one moving from the west towards the east. Very likely, also, the migration involved a nesting population restricted to a relatively small area in central British Columbia, and which might perhaps be regarded as a western expansion of the Peace River population. It is to be noted that during explorations about Bulkley Lake, Francois Lake and places farther to the northwest in 1944, no white-throated sparrows were observed. The farthest west record fot the interior is Kispiox Valley where on June 21, 1921, the male of a pair of breeding birds was collected by H. S. Swarth (Swarth 1924).

Melospiza lincolni (Audubon), Lincoln Sparrow.—A summer visitant, very much less plentiful than the song sparrow. No large spring migration was observed; a few singing males recorded on May 21, May 24 and May 30 may possibly have been late transients. None was seen again until June 27 when two pairs, at least, were feeding young in a willow swamp near Bradley's Slough. Again on July 16, at different places amongst willows and alders, three adults, very much concerned for the safety of young, came close to me, fluttering their wings and uttering alarm notes. Similar observations were made in 1946; on June 27 four pairs were seen feeding young.

Five birds recorded on August 21 probably represented individuals amongst the first wave of autumn transients; others were observed on August 27 and by August 31 the species was relatively common in suitable habitats everywhere. The migration still was in progress on September 3.

Two nests, each containing eggs, were collected at Fort St. James on June 27, 1889 (Mair and MacFarlane 1908).

Melospiza georgiana (Latham), Swamp Sparrow. — At least three pairs nested in willow thickets near Bradley's Slough. One, or both members, of each pair, observed several times between June 27 and July 4 at a distance of a few feet, acted in the manner characteristic of nesting birds. That is to say they became much excited at my presence, fluttering over the ground and chirping continually. However, I was unable to find either nest or young. Single birds recorded later, July 23, August 29 and September 2, possibly were transients.

An adult male, and a young male molting to first-winter plumage, were collected. The only other record for British Columbia west of the Rocky Mountains is one specimen taken, August 4, 1919 at Vanderhoof by Spreadborough.

Melospiza melodia (Wilson), Song Sparrow.—During the first two weeks in May song sparrows were scarce, and most of those observed were also heard singing. It would seem, therefore, that the males arrive some time before the females. By May 21 the species had become more numerous and pairs were established in all the willow thickets visited. A week later, approximately, it was noted as one of the commonest species with populations, in the most desirable habitat, reckoned at seven pairs to the acre.

All of the eight nests found were built above ground, in various species of bushes. The material used in nest construction (such as could readily be seen during necessarily casual examinations) consisted largely of dry grass with horsehair and other types of hair in the linings (See table 3). The founda-

TABLE 3.—Nests of Song Sparrows at Nulki Lake.

Number	Date	Nest Site	Height above ground in inches	Material in nest	Number of eggs
1	Jun. 12	dwarf birch	4	fine grass	4, plus 2 cowbird eggs
2	Jun. 28	black twin-berry	6	coarse and fine grass, moose hair in lining	4, plus 1 young cowbird
3	Jul. 4	black twin-berry	6	grass, lined with horsehair	4
4	Jul. 2	choke cherry	8	grass, lined with black horsehair	4
5	Jul. 2	black twin-berry	12	grass, lined with black horsehair	4
6	Jul. 3	dogwood	18	grass, white deer hair in lining	4
7	Jul. 6	soopolallie	6	grass, black horsehair in lining	4
8	Jul. 20	service berry	4	grass, black horsehair in lining	4

tion in one of two used nests, pulled apart for examination, contained strips of aspen bark, the other coarse sedge fibers and aspen leaves.

The eggs constituting a clutch usually showed uniformitiy in size, ground color and markings. In some clutches the eggs were slightly elongate, the ground color pale greenish-white, the spotting fine, dark and more conspicuous about the larger end; in another type, decidedly different from the first, the eggs were more round, the ground color bluish, with larger brownish markings somewhat evenly distributed. Numerous variations between these two types were noted. One clutch contained an egg so much larger, and so much more heavily spotted than the other three, which were uniformly freckled with cinnamon-color, as to suggest two females had contributed to the clutch.

The first juvenile out of the nest was recorded on June 30 but it was not until July 25 that young were at all plentiful; probably these were the product of a second nesting. Males were heard singing as late as August 2, but the population, both adults and young, became perceptibly smaller by August 16, and by August 22 song sparrows had become scarce. A few, however, even as late as August 30, were still feeding young out of the nest.

Black twin-berries were fed to the young in sufficient amounts to stain the nest rims purple from the voided debris. Several times at Tachick Lake adult song sparrows were watched as they foraged over an expanse of lily pads, sometimes as far as 50 feet from the shore. Undoubtedly they were feeding on the abundant larvae of the lily pads beetle.

The population in 1946 was considerably smaller than it had been in 1945; indeed, song sparrows were much less common than white-throated sparrows. Thus on June 11 only four singing males were located on about 50 acres of bottomland along Sinkut Creek. It seemed probable that the large destruction of young by *Protocalliphora* during the summer of 1945 was responsible for the reduced population in 1946. The subspecies is *Melospiza melodia inexpectata* Riley.

Plectrophenax nivalis (Linnaeus), Snow Bunting. — Present in stubble fields at Nulki Lake during most of the winter of 1945-46 (Lakes District School record).

THE MAMMALS

The study of small mammals by means of systematic trapping in various types of habitat was pursued at Nulki Lake during the period May 12 to 20, 1945. In that time a total of 72 specimens, representing five species, was taken in 215 trap nights. Details of the catch are as follows: *Sorex cinereus*, 1; *Eutamias amoenus*, 3; *Peromyscus maniculatus*, 40; *Clethrionomys gapperi*, 9; *Microtus pennsylvanicus*, 19. Trapping was resumed, at Sinkut Lake and on the north slope of Sinkut Mountain, on August 19 and continued until August 23. Six species were represented amongst a total of 27 specimens taken in 52 trap nights, the particulars being as follows: *Sorex cinereus*, 3; *Sorex obscurus*, 1; *Peromyscus maniculatus*, 6; *Synaptomys borealis*, 1; *Clethrionomys gapperi*, 8; *Microtus pennsylvanicus*, 7; *Zapus princeps*, 1.

Mr. Henry, trapping in three localities, recorded the capture of 213 ani-

mals in 1122 trap-nights as itemized below: Nulki Lake, June 14 to July 28: *Sorex cinereus*, 1; *Peromyscus maniculatus*, 49; *Clethrionomys gapperi*, 4; *Microtus pennsylvanicus*, 74; *Zapus hudsonicus*, *Zapus princeps*, 7; *Mus musculus*, 19; 154 animals captured in 755 trap-nights.

Sinkut Mountain, summit, August 1 to 3: *Eutamias amoenus*, 2; *Peromyscus maniculatus*, 13; *Synaptomys borealis*, 3; *Clethrionomys gapperi*, 2; *Microtus pennsylvanicus*, 7; *Microtus longicauda*, 1. 28 animals captured in 69 trap-nights.

Cluculz Lake, August 6 to 21: *Sorex cinereus*, 5; *Peromyscus maniculatus*, 10; *Synaptomys borealis*, 1; *Clethrionomys gapperi*, 8; *Microtus pennsylvanicus*, 6; *Zapus princeps*, 1. 31 animals captured in 298 trap-nights.

These investigations indicate that *Microtus pennsylvanicus* and *Peromyscus maniculatus* had reached what seemed to be peaks of abundance, that *Clethrionomys gapperi* and *Zapus princeps* were relatively common, and that shrews of the genus *Sorex* were scarce. More particulars are included in the following annotated list.

In 1946 only sufficient trapping to estimate the current numerical status of common species was attempted. Eighteen captures were made in 104 trap-nights, the species and numbers of each being: *Sorex cinereus*, 1; *Peromyscus maniculatus*, 5; *Clethrionomys gapperi*, 4; *Microtus pennsylvanicus*, 8. The results seemed to indicate that the species trapped were no less abundant than they had been in 1945.

The destruction or damage caused by ants, to specimens taken in the ordinary type mouse-trap, is an experience familiar to most investigators. In the Lakes District ants were so enormously abundant that the percentage of specimens destroyed by them was very high. Only by visiting the traps frequently during the day was it possible to obtain a sufficient number of usable specimens.

Opportunities for observing the larger mammals were few. Only occasionally was a moose, a mule deer or a coyote seen, but signs of their presence commonly were encountered. Coyote scats were collected and their composition analyzed, so also were a small number of timber wolf scats and bear droppings. I was fortunate in obtaining photographs of the rather rare animal *Marmota monax petrensis*.

ANNOTATED LIST OF MAMMALS

Sorex cinereus Kerr, Cinereus Shrew.—Very scarce at Nulki Lake, a female with five embryos trapped, May 18, one taken from the nest of a saw-whet owl, and three young trapped in *Microtus* runways under dead willows close to a small lake in the lodgepole pine woods, being the only records for Nulki Lake. Five were trapped at Cluculz Lake in 298 trap-nights.

Sorex obscurus Merriam, Dusky Shrew.—One record only, an adult male taken August 23 at the same place and under the same conditions as were the young cinereus shrews.

Myotis lucifugus (LeConte), Little Brown Bat.—Small bats, seen several times in the headlights of the car while driving through aspen woods, were thought to be of this species.

On June 17, a day of bright sunshine, a large bat of a species unknown to me, was watched as it circled over Bradley's Slough. The flight was swallow-like but much slower; obviously the animal was feeding.

Ursus americanus (Pallas), Black Bear.—A few black bears frequented the Lakes District; their tracks and faecal deposits were found at different times in various places. In June, 1945, one fed for a week or more in a forest-meadow near Nulki Lake, and travelled over a trail leading through aspen woods to the meadow. Droppings were composed of green sedges and other vegetation. Near one faecal deposit the animal had scraped away a large ant hill to its foundation. About June 24 a large bear killed a new-born calf and dragged it into the brush. This was the only instance of the destruction of stock by bears reported during the summer.

On June 26, 1946, I came suddenly on a small bear in a willow swamp. It rushed from cover and galloped along the trail ahead of me. Later in the summer settlers killed two medium-sized animals there and I found the carcass of a two-year-old animal beside Bradley's Slough. Most of this had been eaten by coyotes.

On August 19, 1945, tracks of a large bear, and a faecal deposit composed of blueberries, were observed on the trail to Sinkut Mountain summit. This animal, or another, was seen by berry pickers a few days later.

Most of the bears in the district are black; an exception was a very large brown female killed by a settler about five miles north of Vanderhoof on June 22, 1945. This animal when shot was accompanied by a black bear of smaller size.

Ursus sp., Grizzly Bear.—Several persons, known to be reliable, told me that grizzly bears inhabit a range of hills adjacent to Tatak Lake, which is 25 miles south of the Lakes District. This would seem to be about the nearest point at which the species has been seen within recent years.

Mustela erminea Linnaeus, Short-tailed Weasel. — Not common locally. One was seen at Nulki Lake on August 15, another collected in the Sinkut Meadows, August 25, and a young female was found dead on the Sinkut Mountain trail, August 19. This animal had a long rip on one flank and the skull was crushed. Undoubtedly it had been killed by some large predator, perhaps a coyote. The subspecies is *Mustela erminea richardsonii* Bonaparte.

Mephitis mephitis (Schreber), Striped Skunk. — Apparently rare in the Lakes District; I saw none there in 1945 or 1946. One was shot at North Bay, Nulki Lake, in the autumn of 1945.

Canis latrans Say, Coyote. — In 1945 the bounty paid by the Provincial Government for the destruction of coyotes had recently been increased from two to five dollars, this sum applying to pups as well as to adults. In conse-

quence the hunting of coyote dens, by Indians and by some white settlers, received more than the usual amount of attention.

It is believed locally that coyote pups are born in late April or early May. Exact data are lacking but I have one report concerning a litter of seven, about three weeks old, taken from a den on May 17, and another of a litter of four taken on May 27.

Much is said about the current prevalence of mange in coyotes but no definite figures showing what percentage of the population was affected, as indicated by the condition of skins surrendered for bounty, could be obtained.

Coyotes were heard frequently at night, and occasionally during the day an animal was seen crossing a wood road, on a beach or at the edge of the forest. Judged on the basis of the large number of scats found the species had been abundant during the winter and continued to be so. The animals seem habitually to travel through the edge of the forest, where it impinges on grasslands or cultivated fields. A large number of the winter scats recovered at Nulki Lake were in such places, many under spruce trees where drooping branches came close to the ground. Probably such places are chosen because there the ground would be bare when exposed places were covered by snow; or the depth of snow under such shelters would be considerably less than elsewhere. Faintly marked trails through the vegetation on slough margins also were travelled extensively. So was the trail up Sinkut Mountain, judging by the number of scats, representing both summer and winter, that had been dropped there. Many summer scats were found in open fields, usually on a slight elevation that provided a view for some distance.

Information on the food habits of coyotes obtained from the examination of 61 winter scats and 45 spring and summer scats is summarized below.

NULKI LAKE, 26 winter scats

Snowshoe Rabbit This item alone, or mixed with clay, constituted the sole food remains in 19 of the 26 scats examined; it represented smaller percentages in four other scats and was absent from three.

Domestic Fowl Feathers and bones of white fowls were the only food remains in one, and represented 5, 20, 60, 60 and 70 per cent, respectively, in five other scats.

Horsehair Present in two scats, in one representing 30 per cent of the total (which otherwise consisted of rabbit fur), and in the other representing 5 per cent, the other items being domestic fowl 20 per cent and clay 75 per cent.

Ruffed Grouse One occurrence, a number of feathers in a scat otherwise composed of rabbit fur.

Vegetation One scat contained a small amount, 10 per cent, of vegetable debris identified as dry aspen leaves.

Clay Present in amounts from 3 to 75 per cent (average 26.3 per cent) in 14 of the 26 winter scats examined.

NULKI LAKE, 35 spring and summer scats

Snowshoe Rabbit Bones and fur of rabbit were present in 12 of the 35 summer scats, in amounts ranging from 15 to 100 per cent of the total material.

Woodchuck Woodchuck hair was the sole constituent of eight scats found in one

place at Manson's Slough. Very likely these were deposited by a single coyote. Another scat recovered in a spruce thicket contained two upper incisors, and bone fragments, in addition to hair.

Meadow Mouse This item was the sole constituent of two; it represented 90 per cent of a third, and 10 per cent of a fourth scat, all found in the Sinkut Meadows.

Domestic Fowl Present in three spring scats, representing 90 per cent of the material in one, 80 per cent in another and 10 per cent in a third.

Moose Indicated by a few hairs in each of two scats.

Birds One scat contained a few feathers, probably those of a red-wing blackbird.

Eggs Traces of egg-shell and the thickened integument of a long-incubated egg, all probably representing duck eggs, were detected in three scats. In two the main item composing the scat was *Microtus* hair; in the other rabbit was the chief constituent. All were found in the Sinkut Meadows.

Service berries Four scats found in late July were composed entirely of seeds and skins of this berry; in two others it represented 99 and 85 per cent, respectively, and in another five per cent of the total material. The last was otherwise composed of rabbit fur and bones.

Miscellaneous Vegetation In this category are placed one occurrence of a small amount of fine grass, one occurrence of a coarse sedge that represented 50 per cent of the total material in a scat, and six occurrences of miscellaneous vegetable debris that included a trace of *Equisetum*, spruce needles, spruce cone scales, and other unidentified material. The grasses probably were taken as food; the miscellaneous debris in each of the scats represented was combined with forest loam, either as a minor or a chief constituent. Possibly the animal had eaten this material from the same necessity which impels it to eat clay.

Forest Loam In one scat this material represented 90, in two 85, in one 80 and in another 4 per cent of the total material. In each the only other constituent was vegetable debris.

Clay Present in seven scats, usually as a minor item representing 2 to 5 per cent of the total bulk; however in one it constituted 10, in another 30 and in a third 40 per cent of the total.

SINKUT MOUNTAIN, 25 winter scats

Snowshoe Rabbit Present in all but four of the 25 winter scats examined, constituting 100 per cent in 16 and 15 to 40 per cent of the total in the remaining five.

Mule Deer Three scats were composed solely of this item, another to the extent of 95 per cent. The material consisted of fawn hair and one fawn toe.

Moose Moosehair formed 30 per cent of the material in one scat otherwise composed of loam and vegetable debris.

Vegetable Debris One occurrence, with moose hair.

Forest Loam One occurrence, with moose hair.

Clay In one scat clay composed 5, in two 80, in two others 85 per cent of the total material. In one it was combined with mule deer hair, in four others rabbit fur was the only other constituent.

SINKUT MOUNTAIN, 6 summer scats

Snowshoe Rabbit Present in all six scats, being the exclusive item in one and 40 to 60 per cent of the total material in the other five.

Vegetation Unidentified, green vegetable material was the only other item in the summer scats from Sinkut Mountain, and represented 41.7 per cent of the total material in all six.

CLUCULZ LAKE, 10 winter scats

Snowshoe Rabbit The sole item in nine scats.

Moose Moose hair composed 10 per cent of one scat that otherwise was composed of forest loam and vegetable debris.

CLUCULZ LAKE, 4 summer scats

Snowshoe Rabbit This item represented 20, 15 and 20 per cent, respectively, of the material in three of the four scats examined. In each it was combined with service berry.

Woodchuck One scat was composed of woodchuck hair, 95 per cent, and service berry, 5 per cent.

Service berry Present in all four scats, in combination with smaller amounts of rabbit fur, and as a minor item combined with marmot hair.

Canis sp., Timber Wolf. — Timber wolves have recently become more common in the Vanderhoof region, as they have elsewhere in central British Columbia. Mr. Charles Davidson, who operates a trap-line from Stuart River to Marguerite Lake, trapped 15 in the winter of 1943-44 and 10 in the winter of 1944-45. Residents of the Lakes District told me of seeing single wolves during the past winter and several were reported while I was there. Thus on June 14 a large, black wolf was seen crossing a field in the Sinkut Meadows, and this animal, or another similar one, was seen a week later beside the road near Stony Creek. On the night of May 18 one was heard howling from a position close to our cabin.

The Lakes District population probably makes its home on Sinkut Mountain; this was the only place where scats were found. One of two winter scats was made up entirely of rabbit fur and bones, the other of moose hair and unidentified debris. One of the spring scats was composed of 45 per cent moose hair mixed with vegetable debris, the only other constituent; the other consisted of moose hair, 45 per cent, and earth mixed with vegetable debris in about equal proportions.

Marmota monax (Linnaeus), Woodchuck.—A rare mammal in the Lakes District known to only a few of the residents there. On May 24, in the thick woods at Bradley's Slough, one was seen stretched out on a fallen aspen that lay several feet above an old aspen stump under which was the animal's burrow. Another, a nursing female, seen by the roadside on July 14, proved to be exceptionally tame although apparently in good physical condition. Perhaps she had wandered far from her burrow—none was found near the place where she first was seen — at any rate her actions when approached were, either to crouch and make a rattling sound with her teeth, or to rush to some nearby position and there turn and face us. In turn she took refuge at the base of a spruce tree, on the trunk of a fallen aspen 10 feet above ground, on a prostrate log and in thick brush. At several of these places photographs were taken at distances of a few feet (Fig. 36).

That woodchucks are preyed upon by coyotes was indicated by the presence of woodchuck hair in scats deposited by at least two coyotes.

The woodchuck first referred to was collected; it is identified as *Marmota monax petrensis* Howell.

Specimens of the flea *Thrassis spenceri* Wagner were taken from this animal.

Eutamias amoenus (Allen), Chipmunk.—Present in small numbers in the aspen woods of the Lakes District and on Sinkut Mountain to the summit.

The subspecies is *Eutamias amoenus septentrionalis* Cowan.

Specimens of the flea *Monopsyllus eumolpi eumolpi* (Roths.) were taken from one chipmunk.

Tamiasciurus hudsonicus (Erxleben), Red Squirrel.—Noted as not abundant. Each small spruce stand in the aspen woods was, or had been earlier, inhabited by one or two squirrels. Old middens were composed exclusively of spruce cone scales as were the remains of casual feedings on stumps, logs and other places through the forest.

The subspecies is *Tamiasciurus hudsonicus columbiensis* Howell.

Specimens of the flea *Monopsyllus vison* Baker were collected from one of these animals.

Glaucomys sabrinus (Shaw), Flying Squirrel.—Apparently not common in the Lakes District. Several persons told me of seeing them at different times in the past, but I saw no live ones and no specimens were taken in my traps. The dried-up carcass of an adult was found caught in the barbs of a barbwire fence at Nulki Lake.

Castor canadensis Kuhl, Beaver.—At one time beaver colonies were located on Stony Creek, on Sinkut Creek and on other suitable waters in the Lakes District—the district is now one of the many trapped-out areas of central British Columbia. A managed trap-line about 20 miles north of the Nechaco River probably is the point nearest to Vanderhoof where beaver are taken on the basis of a sustained, annual crop.

Peromyscus maniculatus (Wagner), White-footed Mouse.—Abundant in the Lakes District where a total of 40 adults was trapped May 12 to 20, in 215 trap-nights. Specimens were taken in all types of habitat, in buildings, in aspen woods, in spruce stands, and in *Microtus* runways through sedges and through brushy coverts. Two adults and 11 young were trapped on the summit of Sinkut Mountain, August 1 to 3, in 69 trap-nights.

One, trapped at Nulki Lake on May 14, contained five large embryos, as did another trapped on May 15. One adult female taken on the last date was not pregnant. In the early part of August young animals were abundant everywhere.

Very likely the *Peromyscus* population had reached a peak of abundance; the finding of nine adults and sub-adults dead on forest trails suggested that a rapid decline in numbers was imminent.

Measurements of 22 adult *Peromyscus maniculatus*

Locality	Number	Total length	Tail Vertebrae	Hind Foot
Nulki Lake	11 males	176.82 (167-187)	87.90 (79-95)	20.54 (20-21)
Nulki Lake	9 females	174.33 (170-188)	85.77 (78-91)	20.00 (19-21)
Sinkut Mtn. Summit	2 females	186.50 (182-191)	93.00 (93-93)	20.50 (20-21)

The subspecies is *P. m. borealis* (Mearns).

Specimens of the flea *Malaraeus telechinum* (Roths.) were taken from a white-footed mouse.

Neotoma cinerea (Ord), Wood Rat.—A wood rat's house, built at the base of an old, dead aspen in a spruce and aspen woods at Nulki Lake, was examined several times in early May. It was made of weathered aspen branches and a smaller number of spruce twigs. Many twigs had crumbled with age and the resulting soft material together with earth, leaves and rubbish filled the interstices to form an almost solid mass five feet in diameter and three feet in height. An entrance in the top, and runways alongside it and through an adjacent partly-hollow aspen log, showed that the house was occupied. Later an adult male and an adult female were trapped there.

Another similar house, also occupied, was found in an identical situation about one-half mile distant. On June 14 a number of fresh black twin-berry branches, with green leaves attached, were piled on top of the house; a single branch had been thrust into the entrance of a woodpecker's nest 10 feet above ground in the aspen stub against which the wood rat's house was built.

The stomachs of the two animals trapped contained masses of comminuted, green vegetation.

The subspecies is *Neotoma cinerea saxamans* (Osgood).

Specimens of the flea *Orchopeas sexdentalus agilis* (Roths.) were collected from a wood rat.

Synaptomys borealis (Richardson), Lemming Vole.—Five specimens were trapped, three on the summit of Sinkut Mountain, one beside a small lake on the flank of this mountain, the fifth at Cluculz Lake.

On geographical grounds the subspecies is referred to *Synaptomys borealis dalli* (Merriam).

Clethrionomys gapperi (Vigors), Red-backed Vole.—Nine adults were trapped, May 12 to 20, in aspen and spruce woods, in 215 trap-nights. During late August a crop of garden peas, grown with other vegetables in a patch of ground close to the wooded margin of Sinkut Creek, attracted numerous adults and young of this species. These animals together with a smaller number of jumping mice were feeding on the ripening peas. During four days eight specimens were taken in nine traps set in the rows of peas.

On geographical grounds the subspecies is referred to *Clethrionomys gapperi saturatus* (Rhoads).

Microtus pennsylvanicus Ord, Meadow Vole. — Very abundant in wet meadows and in grasslands, common in several other types of habitat. Thus 19 adults were taken, May 12 to 20, in 215 trap-nights from sets made along the margin of aspen-bluffs; later in the more favored meadow habitat it was not unusual to have a 50 to 75 per cent efficiency with a group of six to eight traps. On one occasion six traps captured seven voles in 24 hours.

Although in general so abundant, some places once heavily populated were found to be abandoned, or nearly so. Thus the edge of a meadow slough near Nulki Lake was riddled with holes and tunnels, runways crossed every grass-patch and led under every fallen tree. Yet no voles were seen there nor were any taken during several nights' trapping. Similar conditions prevailed in certain soopolallie shrubberies, isolated in the grasslands. These last, however, probably were used only in winter. The piles of winter faeces and the numerous workings indicated a dense population had wintered there.

The subspecies is *Microtus pennsylvanicus drummondi* (Audubon and Bachman).

Microtus longicaudus (Merriam), Long-tailed Vole. — An adult male trapped on the summit of Sinkut Mountain is the only record. This specimen appears to represent the subspecies *Microtus longicaudus vellerosus* Allen.

Ondatra zibethica Linnaeus, Muskrat. — It is reported that the number of muskrats in the Lakes District have declined in the last few years. The population on Bradley's Slough in May probably did not exceed 10 adults although this place has not been trapped since 1942. The catch for that year was 50, for the year previous 99. A trapper operating on the west end of Sinkut Lake took only 37 muskrats during the 1945 season.

The Bradley Slough muskrats excavate dens in the low tree-covered banks; deep runways lead from open water, through the sedge growth, to the tunnels. No houses nor vestiges of old ones were found anywhere on the slough. No round-stem bulrushes grow there; the muskrats' main item of vegetative diet appears to be the soft lower stems of a large sedge, *Carex rostrata*. On an evening in the late summer several muskrats were watched as they swam about within a small area near the center of the slough apparently engaged in eating the surface foliation of *Potamogeton*.

No muskrats, nor any houses, were observed in the more extensive marshes on Nulki and Tachick Lake—territories much more suited to their requirements than is Bradley's Slough. It was concluded that the population in the Lakes District is notably small.

Mus musculus Linnaeus, House Mouse. — Exceedingly numerous in each of several old buildings where grain had been stored, and in occupied fowl-houses where surplus grain always is available.

Zapus hudsonicus (Zimmerman), Hudson Bay Jumping Mouse. — Not common; two specimens trapped at Nulki Lake, July 16, July 21.

Zapus princeps Allen, Rocky Mountain Jumping Mouse.—None taken in

any habitat until mid-June. Later a total of 10 was trapped, chiefly in wet meadows and willow thickets.

Erethizon epixanthum Brandt, Porcupine.—Not common in the Lakes District; one was killed by a farmer at Sinkut Creek on June 6; one was seen by the roadside near Stuart Lake on July 26.

Lepus americanus Erxleben, Snowshoe Rabbit.—In 1945 snowshoe rabbits were seen daily in the aspen woods and alongside the road between the Lakes District and Vanderhoof, nine being counted there on May 3. None was in full summer pelage at that time.

Indications of winter feeding on aspen bark were conspicuous in the bare spring woods. Aspens up to five inches in diameter had been girdled for a height of 12 to 14 inches above ground, the upper more recently barked area colored pale yellow, the lower portion stained and weathered. In other places prostrate aspens, up to six inches in diameter near the base, had been completely denuded of bark on trunk and branches. These skeleton-like trees were conspicuous objects in the dark woods.

As stated elsewhere in this paper snowshoe rabbits form the main food of coyotes, and are eaten extensively by horned owls. The rabbit population in 1945 could not be described as large; very likely heavy predator pressure is an effective control. More rabbits were seen in spring than in late summer.

In 1946 rabbits were much less plentiful. Little evidence of winter-feeding on aspen bark during the previous winter was detected. It was estimated, in June, that the population had been reduced by 80 per cent.

The subspecies is *Lepus americanus pallidus* Cowan.

Odocoileus hemionus (Rafinesque), Mule Deer.—A small population frequented the bottomlands of the Lakes District, and females, one accompanied by a fawn, were regularly seen there. Mr. Phil Brown counted nine deer in a clover field near the west end of Tachick Lake on the evening of May 15.

The Lakes District is reported to be a summer range only; deer are scarce in autumn and entirely absent in winter.

Alces americana (Clinton), Moose.—According to local report the Lakes District supports a large moose population in winter. This was corroborated by observations, in early May, of brush extensively browsed, and the very large amounts of droppings along the shore of Nulki Lake, in the fields, the aspen woods, the shrubberies and the willow swamps. The shrub most commonly browsed in winter is service berry and where this shrub grew amongst, or close to, other species it was eaten in preference to the others; where it was dominant over large areas evidence of heavy browsing was usual. Other shrubs eaten are listed in what appeared to be the order of their preference, viz., dogwood, willows, choke cherry and soopolallie. I could find no evidence, in the bottom lands, of aspen being eaten but I was informed that in places on the side hills young aspens winter-browsed by moose have been observed.

Moose occasionally were seen during the summer. Thus at Bradley's Slough at 10:00 a.m., June 8, a female suddenly appeared in a narrow marsh between the water's edge and the forest. She walked out to knee-depth and fed there, submerging head and forward part of neck for several seconds at a time. When she withdrew her head cascades of water fell from it and long strings of pondweed could be seen hanging from either side of her mouth (Fig. 37). Moose also visited Manson's Slough to feed on *Potamogeton*. Tracks leading through the encircling sedges to the inner ponds were noted frequently and once a large male came to the slough while I was there.

On June 14 a female followed by twin calves swam out some distance into Middle Bay, then turned and swam back to shore. Here she stood until the calves, one 20 yards or more behind the other, reached her side, then all three walked into the woods. Moose also were seen several times beside a small lake in the lodgepole pine woods referred to several times earlier in this paper.

The winter population was reported as even larger during the winter of 1945-46. In June I noted where willows three inches in diameter had been barked to a height of seven feet. In a swamp at Middle Bay a species of willow, with wide leaves silvery below, *Salix bella* Piper, was heavily browsed. It was observed in late August that many of the branches, because of the pruning by moose, had sent out new shoots some up to five feet in length; this particular thicket contained a greater amount of browse in 1946 than in 1945. In July a last-year's calf, sometimes accompanied by a cow, came several evenings in succession to graze in an oat field that sloped upward to an aspen wood from which the calf came, and into which it disappeared again.

At Bradley's Slough, August 21, tracks in the deep, sticky mud of the shore, showed where moose had fed on the abundant arrowhead stranded at the water's edge.

REFERENCES

GUBERLET, JOHN E. AND H. H. HOLSON 1940—A fly maggot attacking young birds with observations of its life history. Murrelet, 21(3): 65-66.

HARMON, DAVID WILLIAM 1820— Voyages and Travels in the Interior of North America.

MACOUN, JOHN 1877—Report of Progress, Geological Survey, 1875.76: 132. Published by authority of Parliament.

MAIR, CHARLES AND RODERICK MACFARLANE 1908—Through the Mackenzie Basin. A narrative of the Athabasca and Peace River Treaty Expedition of 1899, by Charles Mair. Notes on the mammals and birds of Northern Canada, by Roderick MacFarlane. William Briggs, Toronto.

SWARTH, H. S. 1922—Birds and mammals of the Stikine River region of Northern British Columbia and Southeastern Alaska. Univ. Calif. Publ. Zool. 24(2): 125-314, plates 8, 34 text figs.

———1924—Birds and mammals of the Skeena River region of Northern British Columbia. Univ. Calif. Zool. 24(3): 315-394, plates 9-11, 1 text fig.

INDEX

Accipiter cooperi, 66
gentilis, 66
striatus, 66
Acknowledgments, 3
Actitis macularia, 77
Æchmophorus occidentalis, 43
Aegolius acadicus, 85
funereus, 85
Agelaius phoeniceus, 110
phoeniceus arctolegus, 112
Alces americana, 132
Anas acuta, 48
carolinensis, 49
discors, 50
platyrhynchos, 46
Anser albifrons, 45
Anthus spinoletta, 105
Ants, 5, 36, 37, 89, 93, 94, 114, 124
Aquila chrysaetos, 68
Ardea herodias, 44
Arenaria melanocephala, 76
Asio flammeus, 85
otus, 84
Aythya americana, 56
affinis, 59
collaris, 57
marila, 59
valisineria, 58

Baldpate, 15, 18, 19, 20, 23, 24, 27, 29, 32, 33, 34, 47, 48, 53, 56, 84
Bat, Little Brown, 124
Bay, Middle, 6, 12, 29, 34, 47, 50, 54, 57, 58, 60, 76, 112
North, 12, 46, 125
South, 12, 42, 76
Bear, Black, 125
Grizzly, 125
Beaver, 129
Berries, as food for birds, 38
Bird Sanctuary, Nechaco River, 45, 46
Birds of Northern Canada, 3
Bittern, American, 19, 23, 44
Blackbird, Brewer, 7, 10, 33, 37, 112
Red-wing, 7, 13, 27, 33, 37, 110
Rusty, 28, 33, 41, 112
Yellow-headed, 33, 109
Bluebird, Mountain, 30, 104
Bombycilla cedrorum, 105
garrulus, 105
Bonasa umbellus, 71
Botaurus lentiginosus, 44
Branta canadensis, 45
leucopareia, 45
minima, 45
Bubo virginianus, 83
Bucephala albeola, 62
clangula, 60
islandica, 61
Buffle-head, 11, 15, 18, 19, 23, 24, 27, 29, 35, 62
Bunting, Snow, 123
Buteo harlani, 67
jamaicensis, 66
jamaicensis calurus, 67
krideri, 67
lagopus, 67
swainsoni, 67

Canachites franklini, 71
Canis latrans, 125
Canis sp., 128
Canvas-back, 18, 29, 58
Capella gallinago, 76
Cariboo Parklands, 4, 93
Carpodacus purpureus, 114
Castor canadensis, 129
Ceratophyllus niger, 90
Charadrius hiaticula, 76
vociferus, 76
Chen hyperborea, 45
rossi, 46
Chickadee, Black-capped, 6, 101
Hudsonian, 101
Mountain, 10, 101
Chipmunk, 11, 70, 129
Chlidonias nigra, 82
Chordeiles minor, 90
Cinclus mexicanus, 101
Circus cyaneus, 69
Clethrionomys gapperi, 90, 123, 130
gapperi saturatus, 130
Colaptes auratus, 92
cafer, 93
Colymbus auritus, 43
grisegena, 42
nigricollis, 43
Contopus richardsonii, 96
Coot, American, 13, 18, 19, 23, 24, 27, 54, 74
Corvus corax, 100
brachyrhynchos, 100
Cottus asper, 42
Cowbird, 31, 36, 113
Coyote, 125
Crane, Lesser Sandhill, 73
Creek, First, 12
Cluculz, 42
Corkscrew, 13, 20, 21, 68, 99
Second, 12, 13
Sinkut, 9, 20, 43, 97, 100
Stony, 13, 16, 17, 18, 19, 43, 52, 57, 59, 61, 65
Tachick, 16

Cristivomer namaycush, 42
Crocethia alba, 79
Crossbill, Red, 10, 115
White-winged, 115
Crow, American, 7, 30, 100
Cyanocitta stelleri, 100
Cygnus buccinator, 44
columbianus, 44

Deer, Mule, 127, 132
Dendragopus, obscurus, 70
Dendrocopus villosus, 95
pubescens, 95
pubescens leucurus, 95
villosus monticola, 95
Dendroica auduboni, 107
coronata, 107
magnolia, 107
petechia, 107
striata, 108
townsendi, 108
Dipper, 101
Dove, Mourning, 83
Dowitcher, 79
Duck, Harlequin, 64
Greater Scaup, 18, 59
Lesser Scaup, 15, 18, 23, 34, 59
Ring-necked, 18, 19, 27, 57
Ruddy, 15, 18, 19, 24, 64

Eagle, Bald, 30, 41, 66, 68, 69
Golden, 68
Empidonax hammondii, 96
traillii, 96
traillii traillii, 96
wrightii, 96
Eremophila alpestris, 97
alpestris arcticola, 97
Erethizon epixanthum, 132
Ereunetes mauri, 79
pusillus, 79
Erismatura jamaicensis, 64
Erolia bairdii, 78
melanotos, 78
minutilla, 78
Euphagus carolinus, 112
cyanocephalus, 112
Eutamias amoenus, 123, 129
amoenus septentrionalis, 129

Falco columbarius, 70
mexicanus, 70
sparverius, 70
Falcon, Prairie, 70
Finch, Purple, 6, 33, 37, 114
Fishes, List of, 19
Flicker, Yellow-shafted, 10, 30, 33, 92
Flycatcher, Alder, 7, 22, 33, 96
Hammond, 33, 96
Olive-sided, 97
Wright, 6, 33, 96
Formica rufa melanotica, 5
Fort St. James, 3, 27
Frog, Red-legged, 28
Fulica americana, 74

Gavia immer, 42
Geothlypis trichas, 108
Glaucidium gnoma, 84
Glaucomys sabrinus, 129
Golden-eye, American, 15, 18, 19, 23, 29, 60
Barrow, 15, 18, 19, 23, 24, 61
Goose, Canada, 27, 29, 45
Cackling, 45
Lesser Canada, 45
Lesser Snow, 45
Ross, 46
White-fronted, 45
Goshawk, 66
Grebe, Eared, 18, 43
Holboell, 15, 18, 19, 20, 23, 29, 42
Horned, 19, 43
Pied-billed, 18, 44
Western, 18, 43
Grosbeak, Evening, 33, 114
Pine, 114
Grouse, Blue, 70
Franklin, 71
Ruffed, 71, 126
Sharp-tailed, 73
Grus canadensis, 73
Gull, Bonaparte, 81, 83
California, 81
Herring, 80
Ring-billed, 81
Short-billed, 81
Haliaeetus leucocephalus, 68
Hawk, Cooper, 66
Harlan, 67
Marsh, 7, 30, 69, 97
Pigeon, 70
Red-tailed, 66
Rough-legged, 67
Sharp-shinned, 11, 66
Sparrow, 70
Swainson, 67
Heron, Great Blue, 44
Hesperiphona vespertina, 114
Hirundo rustica, 98
Histrionicus histrionicus, 64
Hummingbird, Calliope, 92
Rufous, 7, 22, 91
Hylatomus pileatus, 93
Hylocichla guttata, 103
guttata guttata, 103
ustulata, 103
ustulata almoe, 104

Invertebrates, List of, 15, 17, 19, 21, 28
Iridoprocne bicolor, 97
Ixoreus naevius, 103

Jay, Canada, 10, 100
  Stellar, 100
Junco, hyemalis, 116
  hyemalis cismontanus, 116
  oreganus, 116
  oreganus montanus, 116
Junco, Oregon, 10, 33, 116
  Slate-colored, 116

Kingbird, Eastern, 95
Kingfisher, Belted, 92
Kinglet, Golden-crowned, 104
  Ruby-crowned, 6, 30, 104

Lagopus lagopus, 71
Lake, Cluculz, 1, 41, 128
  Francois, 1
  Fraser, 1
  lac la Hache, 31
  Nulki, 6, 12, 30, 76, 126
  Puntchesakut, 31
  Sinkut, 20
  Stuart, 39
  Tachick, 16, 75
Lakes District, 1, 5
Lake Shiner, 19
Lanius excubitor, 106
Lark, Horned, 7, 30, 97
Larus argentatus, 80
  argentatus thayeri, 80
  californicus, 81
  canus, 81
  delawarensis, 81
  philadelphia, 81
Lepus americanus, 132
  americanus pallidus, 132
Limnodromus griseus, 79
  griseus scolopaceus, 79
Ling, 19
Lobipes lobatus, 80
Loon, 42
  Black-throated, 3
Lophodytes cucullatus, 65
Loxia curvirostra, 115
  curvirostra bendirei, 115
  leucoptera, 115

MacFarlane, Roderick, 3
Macoun, John, 3
Magpie, Black-billed, 100
Malareus telechinum, 130
Mallard, 7, 19, 46
Mareca americana, 53
Marmota monax, 128
  monax petrensis, 129
Marsh, Collins', 13, 57, 73
Meadowlark, Western, 109
Megaceryle, alcyon, 92
Melanitta fusca, 64
  perspicillata, 64
Melospiza georgiana, 121
  lincolni, 121
  melodia, 122
  melodia inexpectata, 123
Mephitis mephitis, 125
Merganser, American, 41, 65
  Hooded, 41, 65
  Red-breasted, 18, 66
Mergus americanus, 65
  serrator, 66
Microtus longicauda, 131
  longicauda vellerosus, 124, 131
  pennsylvanicus, 85, 90, 123, 131
  pennsylvanicus drummondi, 131
Migration, Bird, 28
Molothrus ater, 113
  ater artemisiae, 114
Monopsyllus eumolpi eumolpi, 129
  vison, 129
Moose, 11, 100, 128, 132
Mouse, White-footed, 129
  House, 131
  Hudson Bay Jumping, 131
  Rocky Mountain Jumping, 131
Museum, Canadian National, 3
  United States National, 3
Muskrat, 131
Mus musculus, 124, 131
Mustela erminea, 125
  erminea richardsonii, 125
Myadestes townsendi, 104
Myotis lucifugus, 124

Neotoma cinerea, 130
  cinerea saxamans, 130
Nephoecetes niger, 91
Nighthawk, 90
Nucifraga columbiana, 101
Nulki Hills, 5, 9
Nutcracker, Clark, 101
Nuthatch, Red-breasted, 6, 10, 101
Nuttallornis borealis, 97
Nyctea scandiaca, 84

Odocoileus hemionus, 132
Ondatra zibethica, 131
Oporornis tolmiei, 108
Orchopeas sexdentalus agilis, 130
Osprey, 69
Owl, Great Gray, 84
  Hawk, 84
  Horned, 83
  Long-eared, 84
  Pygmy, 84

Richardson, 85
Saw-whet, 85
Short-eared, 85
Snowy, 84

Pandion, haliætus, 69
Park, Tweedsmuir, 4
Partridge, European, 73
Parus atricapillus, 101
gambeli, 101
hudsonicus, 101
Passerculus sandwichensis, 115
Passer domesticus, 35, 109
Pediœcetes phasianellus, 73
Pelecanus erythrorhynchos, 44
Pelican, White, 44
Perdix, perdix, 73
Perisoreus canadensis, 100
canadensis canadensis, 100
Peromyscus maniculatus, 129
maniculatus borealis, 130
Petrochelidon pyrrhonota, 99
Pewee, Western Wood, 10, 96
Phalarope, Wilson, 30, 79
Northern, 30, 80
Phoebe, Say, 95
Pica pica, 100
Picoides, arcticus, 95
trydactylus, 95
trydactylus fasciatus, 95
Pinicola enucleator, 114
Pintail, 23, 29, 34, 48
Pipit, American, 7, 30, 69, 105
Piranga, ludoviciana, 114
Plants, list of, 5, 6, 9, 10, 11, 12, 21, 22
Plectrophenax nivalis, 123
Plover, Killdeer, 11, 76
Semipalmated, 76
Podilymbus podiceps, 44
Poœcetes gramineus, 116
Porcupine, 132
Porzana carolina, 73
Prince George, 4, 67
Protocalliphora, 35, 92, 98, 99, 113, 123
hirudo hirudo, 35
splendida hesperis, 35
Ptarmigan, Willow, 71

Quesnel, 4, 9

Rabbit, Snowshoe, 126, 127, 132
Rana aurora, 28
pretiosa, 28
sylvatica, 28
Rat, Wood, 130
Raven, American, 100
Redhead, 15, 19, 56
Redstart, American, 10, 109
Regulus calendula, 104
satrapa, 104
Riparia riparia, 97
River, Nautley, 29
Nechaco, 1, 39
Sinkut (See Sinkut Creek),
Stuart, 41
Tachie, 40
Robin, American, 30, 102
Salamander, 28
Sanderling, 79
Sandpiper, Baird, 78
Buff-breasted, 79
Least, 11, 30, 78
Pectoral, 30, 78
Semipalmated, 79
Solitary, 11, 30, 77
Spotted, 11, 77
Western, 79
Sapsucker, Red-breasted, 10, 30, 94
Yellow-bellied, 94
Sayornis sayi, 95
Scoter, Surf, 15, 64
White-winged, 15, 64
Sculpin, 42
Seiurus noveboracensis, 108
Selasphorus rufus, 91
Setophaga ruticilla, 109
Shoveller, 15, 55
Shrew, Cinereus, 124
Dusky, 11, 124
Shrike, Northern, 106
Sialia currucoides, 104
Sinkut, Mountain, 5, 11, 127
Siskin, Pine, 6, 115
Sitta canadensis, 101
Skunk, Striped, 125
Slough, Bradley's, 4, 21, 29, 74, 75
Manson's, 4, 25, 29, 74
Snipe, Wilson, 30, 76
Solitaire, Townsend, 10, 38, 104
Sora, 73
Sorex cinereus, 124
obscurus, 124
Sparrow, Chipping, 6, 10, 117
Clay-colored, 10, 117
English, 109
Golden-crowned, 119
Lincoln, 10, 121
Savannah, 30, 115
Song, 11, 30, 122
Swamp, 121
Vesper, 116
White-crowned, 30, 118
White-throated, 10, 119
Spatula clypeata, 55
Spinus pinus, 115
Spizella passerina, 117
pallida, 117
passerina passerina, 117

Spreadborough, William, 3, 44, 122
Spyraphicus ruber, 94
varius, 94
varius varius, 94
Squirrel, Flying, 129
Red, 129
Steganopus tricolor, 79
Stelgidopteryx ruficollis, 98
Stellula calliope, 92
Strix nebulosa, 84
Sturnella neglecta, 109
Sucker, Coarse-scaled, 20
Fine-scaled, 20
Surnia ulula, 84
Swallow, Bank, 97
Barn, 98
Cliff, 99
Rough-winged, 98
Tree, 30, 97
Violet-green, 97
Swan, Trumpeter, 44
Whistling, 27, 29, 44
Swift, Black, 30, 91
Synaptomys, 11
Synaptomys borealis, 130
borealis dalli, 130

Tachycineta thalassina, 97
Tamiasciurus hudsonicus, 129
hudsonicus columbiensis, 129
Tanager, Western, 10, 114
Teal, Blue-winged, 7, 50
Green-winged, 49, 66
Telegraph Road, 4
Telmatodytes palustris, 101
palustris plesius, 102
Tern, Black, 15, 82
Thrassis spenceri, 129
Thrush, Hermit, 6, 10, 103
Swainson, 103
Varied, 103
Water, 7, 108
Totanus melanoleucus, 77
flavipes, 78
Tringa solitaria, 77
solitaria cinnamomea, 77
solitaria solitaria, 77
Triturus granulosis, 28
Trout, Kamloops, 19, 20
Tryngites subruficollis, 79
Turdus migratorius, 102
migratorius migratorius, 103
Turnstone, Black, 76
Tyrannus tyrannus, 95

Ursus americanus, 125
Ursus sp., 125

Vanderhoof, 1, 4, 44, 45, 73, 113, 114
Vermivora celata, 106
celata orestera, 107
peregrina, 106
Vertebrate Habitats, Aquatic, 12
Terrestrial, 5
Vireo gilvus, 106
gilvus swainsonii, 106
olivaceus, 106
solitarius, 106
solitarius cassinii, 106
Vireo, Red-eyed, 106
Solitary, 10, 106
Warbling, 6, 106
Vole, Lemming, 130
Long-tailed, 131
Meadow, 7, 69, 80, 131
Red-backed, 130

Warbler, Audubon, 6, 10, 30, 107
Black and White, 3
Black-poll, 108
Macgillivray, 108
Magnolia, 107
Myrtle, 107
Orange-crowned, 106
Tennessee, 106
Townsend, 108
Wilson, 30, 108
Yellow, 107
Yellow-throat, 108
Waxwing, Bohemian, 105
Cedar, 30, 105
Weasel, Short-tailed, 125
Wilsonia pusilla, 108
Wolf, Timber, 128
Woodchuck, 126, 128
Woodpecker, Arctic three-toed, 95
American, three-toed, 95
Downy, 95
Hairy, 95
Pileated, 93
Wren, Long-billed Marsh, 101

Xanthocephalus xanthocephalus, 109

Yellow-legs, Greater, 11, 27, 30, 77
Lesser, 11, 78

Zapus hudsonicus, 131
princeps, 131
Zenaidura macroura, 83
Zonotrichia albicollis, 119
coronata, 119
leucophrys, 118
leucophrys gambeli, 119

Mammal Remains in Owl Pellets*

Ernest C. Driver
Smith College, Northampton, Mass.

The alert field worker has a good deal of the detective in him. He does not need to have an animal in his hands to be aware of its local occurrence, but uses all the clues he can discover. Although his primary interest may be in the welfare of the ruffed grouse or the white-tailed deer, he soon realizes, as Leopold has so well pointed out, that to attain his object he must be an ecologist, aware of the whole series of actions and interactions between all living organisms, and that to increase or decrease the number of any species he must exercise some degree of control over the whole environment. Obviously, any method which will enable him to learn more about the wildlife present in any area will be of value to him. Tracks and tracking methods have been well described by Brunner, Seton, and George F. Mason, identification of hairs by Leon Hausman, and the use of feces or scat as indicators of the presence of certain animals has been suggested by Seton. Still another method of checking the occurrence and seasonal abundance of small mammals, especially rodents, is by the identification of skeletal material found in owl pellets. Owls swallow their prey in large chunks, digest the flesh, and then regurgitate the cleaned bones and fur or feathers. These pellets, from one to six inches long, depending on the kind of owl, may be found under evergreens or wherever owls roost. Once a regular roost or nesting place has been found, one may gather pellets by the hundred. About the only things the beginner might mistake for owl pellets are weathered fox droppings, but the latter almost always contain some vegetable material and, when dry, are definitely dusty, whereas owl pellets contain nothing but clean bone fragments and fur or feathers.

Identification of the bones is somewhat complicated by the owl's habit of killing its prey by crushing the back of the skull. Care must be taken, in handling the bone fragments, to see that the teeth do not drop out when the fur packing is removed. Even if the teeth are lost, however, the sockets give some clue to their shape, size and arrangement. The fragmentary condition makes a general key to the identification of skulls, such as that published by the author in his book, *Name That Animal,* of limited use. The following key has been designed especially for use on owl pellet material, is based on many years of interest in the subject, and has been well tested by people with no special zoological training. It offers two choices under each number. One of these will fit the specimen better than the other, the number at the end of that line indicating the next set of alternatives to be considered, until the name is finally reached. Check lists of local mammals and a check set of skulls of small mammals of the vicinity will, of course, be of much value in verifying the determinations.

* Contributions from the Department of Zoology, Smith College, No. 221.

While a key appears at first sight to be a meaningless array of minor characters, one soon learns the features upon which it is based and can then use it with speed and accuracy. We suggest that the reader get a mouse or rat skull and try out the key on that material rather than try to read or remember the key as it stands. A little use of the key on actual pellet material will soon teach him to recognize the more common material on sight, and he will soon be independent of the key except for the more unusual or rare specimens.

In some seasons when mice or rabbits are abundant there may be little variety in the owl pellets, but at other times the owl may show a widely varied menu. We have found such burrowing forms as pocket gophers and moles represented, and even fish bones, although the latter probably represented scavenger activities of a very hungry owl. Relatively rare forms for the writer's area, such as the pigmy shrew, have turned up more frequently in owl pellets than in other types of collecting. A pellet study extending over several years gives interesting sidelights on the cyclic fluctuation of some species.

KEY TO MAMMAL SKULLS AND REMAINS COMMONLY FOUND IN OWL PELLETS

1. With a large toothless space between incisors (front teeth) and the cheek teeth 7
   No large space between incisors and cheek teeth 2
2. Skull very small, rarely longer than three-quarters of an inch, and with a gap about one-eighth of an inch wide, in middle of upper jaw .....BAT, several genera
   No marked gap in front part of upper jaw 3
3. Teeth all chestnut-colored and not differentiated greatly in size .....SHREW, *Blarina* and *Sorex*
   Teeth not so colored 4
4. Teeth varying in size like those of dog or cat; eye socket large 5
   Canine teeth not much larger than incisors; eye socket very small; leg bone short but stout .....MOLE, several genera
5. Bony roof of mouth extending well back of level of last cheek teeth; hairs usually brown, may be white in winter 6
   Palate not extending beyond level of last cheek teeth; black hairs and white .....SKUNK, *Mephitis* and *Spilogale*
6. Floor of ear region irregular; tooth-bearing portion of upper jaw about an inch long .....MINK, *Mustela*
   Floor of ear region rounded; tooth-bearing part of upper jaw rarely over half an inch long .....WEASEL, *Mustela*
7. Two very small incisors directly behind the upper two large ones 8
   Only two upper incisors (sometimes grooved and so appearing to be four) 9
8. Six upper cheek teeth on each side of upper jaw, the last one very small; bone along side of nose spongy .....RABBIT, *Lepus* and *Sylvilagus*
   Five upper cheek teeth; side of nose not spongy; in Rocky Mountain area .....PIKA, *Ochotona*
9. Skull with a pointed, more-or-less triangular, projection of bone over the top of the eye socket 10
   No such projection over top of eye socket 16
10. Incisors whitish 11
    Incisors orange, at least in front 12

11. Incisor about one-eighth inch wide (from side to side) and one-eighth inch deep (from front to back) ..... WOODCHUCK, *Marmota*

Incisor about one-sixteenth inch wide and one-eighth inch deep ..... PRAIRIE DOG, *Cynomys*

12. Incisor about one-eighth inch deep (from front to back); with a slit-like opening on side of nasal area, just in front of, and above the root of, first cheek tooth 13

Incisor about one-sixteenth inch deep; opening triangular or circular 14

13. Skull usually just over two inches long; openings in inner wall of eye socket separated by more than the width of one of them ..... GRAY *and* FOX SQUIRRELS, *Sciurus*

Skull about one and one-half inches long; openings in inner wall of eye socket separated by about the width of one of them ..... RED SQUIRREL, *Sciurus*

14. Length of cheek tooth row about equal to length between incisor and first cheek tooth; a definite, smoothly curved notch in the bone forming the upper rim of eye socket ..... FLYING SQUIRREL, *Glaucomys*

Cheek tooth row much shorter than the distance between incisor and first cheek tooth; no notch or an irregular one in upper rim of eye socket 15

15. Incisor depth (from front to back) about twice its width; cheek teeth about as wide as long ..... CHIPMUNK, *Tamias* and *Eutamias*

Incisor depth about same as width; cheek teeth wider than long ..... GROUND SQUIRREL, *Citellus*, etc.

16. Upper incisors grooved on front side 17

Upper incisors not grooved 25

17. Incisor large, about one-eighth inch wide, usually orange in front; cheek teeth without definite cusps or triangles of enamel — (Pocket Gophers) 18

Incisor smaller, rarely over one-sixteenth inch wide 20

18. Groove close to inner edge of incisor face, often faint ..... WESTERN POCKET GOPHER, *Thomomys*

Groove almost in center of face of incisor tooth 19

19. Two middle upper cheek teeth with enamel plates on anterior side only ..... RIO GRANDE POCKET GOPHER, *Cratogeomys*

Upper cheek teeth with enamel plates on both anterior and posterior sides ..... EASTERN POCKET GOPHER, *Geomys*

20. Ear region greatly inflated, covering most of side of head; no opening in front part of eye socket; western states only 21

Ear region not inflated; with an opening from side of nose into front of eye socket 22

21. Cheek teeth with U-shaped enamel folds ..... POCKET MOUSE, *Perognathus*

Cheek teeth each with a simple outer margin of enamel .... KANGAROO RAT, *Dipodomys*

22. Groove almost at outer edge of upper incisor; nose short, its length (to back of nasal bones) less than twice its width; cheek teeth without pronged roots; rare ..... LEMMING MOUSE, *Synaptomys*

Groove almost in middle of incisor; length of nose more than twice its width; cheek teeth with pronged roots 23

23. Posterior end of palate squared, sometimes with a median projection; hair brown to ashy; southern and western states ..... HARVEST MOUSE, *Reithrodontomys*

Posterior end of palate evenly rounded; hair from back definitely black-tipped, that from underside white; northern states 24

24. One very small and three large upper cheek teeth on each side ..... JUMPING MOUSE, *Zapus*

Only three upper cheek teeth on each side ..... WOODLAND JUMPING MOUSE, *Napaeozapus*

25. Incisor one-eighth inch wide (from side to side) 26

Incisor considerably narrower 28

26. Area between eye sockets pinched almost to a ridge ..... MUSKRAT, *Ondatra*

Area between eye sockets as wide as the nose region 27

27. With openings in the front part of the palate as long as the cheek teeth row; enamel ridges forming definite triangles on crowns of cheek teeth ..... WOOD RAT, *Neotoma*

With very small openings in front part of palate; enamel not forming triangles on crowns of cheek teeth ..... WESTERN POCKET GOPHER, *Thomomys*

28. Cheek teeth with open or closed enamel triangles in zigzag pattern on crowns, sides sharply ridged 29

Cheek teeth much like human teeth, with two or three rows of rounded cusps or loops, sides with rounded flutings 31

29. Palate on one level and not pitted; cheek teeth with small roots; northern states only ..... RED-BACKED MOUSE, *Clethrionomys*, (*Evotomys*)

Back part of palate on a different level from front part and pitted or spongy 30

30. Cheek teeth of same diameter throughout length, not with restricted roots; common ..... MEADOW MOUSE, *Microtus*

Cheek teeth with small roots (in adults); rare mice found in pine forests of Rocky Mountain and western states ..... TREE MOUSE, "LEMMING" MOUSE, *Phenacomys*

31. Palate ending at level of back of last cheek teeth; skull about one inch long; incisor depth about twice its width ..... WHITE-FOOTED or DEER MOUSE, *Peromyscus*

Palate extending somewhat beyond level of back of last cheek teeth; skull from three-quarters to two inches long 32

32. Long openings in palate, behind front teeth, extending beyond the level of the front of first cheek teeth; skull rarely over one inch long 33

Openings in palate scarcely reaching level of first cheek teeth; skull usually one and one-half to two inches long 34

33. First and second cheek teeth almost equal in size, with two rows of cusps; lower jaw with a long curved process in front of, and higher than, the articulating process ..... GRASSHOPPER MOUSE, *Onychomys*

First cheek teeth almost twice the size of the second, with three irregular rows of cusps; lower jaw with only a small coronary process ..... HOUSE MOUSE, *Mus musculus*

34. Crowns of cheek teeth flattened, with definitely S-shaped enamel folds ..... COTTON RAT, *Sigmodon*

Crowns of cheek teeth bearing cusps 35

35. Large opening between last cheek tooth and palate on each side; cheek teeth with two rows of cusps; southern states ..... RICE RAT, RICE FIELD MOUSE, *Oryzomys*

No such opening or only a very small one; cheek teeth with cusps in three irregular rows 36

36. Space between incisors and cheek teeth about twice the length of cheek teeth row; skull about two inches long ..... BARN, GRAY or NORWAY RAT, *Rattus norvegicus*

Space between incisors and cheek teeth scarcely longer than the length of cheek teeth row; skull about one and one-half inches long ..... ROOF RAT, BLACK RAT, *Rattus rattus*

The North American Chrysopilus

(Rhagionidae — Diptera)

D. Elmo Hardy
University of Hawaii, Honolulu

The following study attempts to bring up to date the Nearctic species of the Rhagionidae genus *Chrysopilus*. Descriptions and notes are given only for the new and little known species. Where they have been adequately described by other workers it has not been felt necessary to repeat the description in this paper.

Members of this genus are distinguished from other Nearctic genera of the family by having the front tibiae without terminal spurs; the hind tibiae each with one terminal spur; the metapleura entirely covered with dense pile; third antennal segment oval or conical in shape with a slender apical arista and the cubital cell closed. They are most closely related to the genus *Ptiolina* but are readily separated by having the aristae distinctly longer than the antennae and the metapleura very densely pilose. In *Ptiolina* the aristae are short and rather broad and the metapleura are bare.

Some of the couplets in the key to the species have been patterned after Leonard,* with the addition of new characters and species. The page number is given for each species discussed in this paper.

Key to Species

1. Wings hyaline, or but faintly light brown fumose 2
   Wings entirely dark brown to blackish or with distinct brown to black markings 31
2. First antennal segment greatly swollen, as in *Symphoromyia*, longer than the second and third segments combined .....*dilatus* Cresson
   First antennal segment small and not swollen except in *tomentosus* Bigot and *proximus* Walker; never over one and one-half times longer than the third segment and usually as small or smaller than the second 3
2. Abdomen velvety black with silvery or golden tomentose bands which may be narrowly interrupted medianly 4
   Abdomen black to yellow in ground color but not velvety. If tomentum is present it is evenly distributed, not arranged in bands 5
4. All femora and halteres entirely pale yellow. Stigma yellowish and indistinct. Front of female shining black .....*ornatus* Say
   Front femora darkened at least basally. Knobs of halteres and stigma brown. Front of female opaque, dark grayish .....4a. *fasciatus* Say
4a. Wings wholly hyaline, except for stigmal spot .....*fasciatus fasciatus* Say
   Tips of the wings infuscated, veins R3, R4 and R5 broadly bordered with brownish .....*fasciatus* var. *infuscatus* Leonard

* Mem. Amer. Ento. Soc., 7: 129-131.

5. Labellum and palpi very small, poorly developed and inconspicuous. The labellum is much shorter than the antennae, minus the aristae. The labellum is bulb-shaped, not flattened, and is only one-half as wide as the facial swelling (fig. 5a) 6

Mouthparts well developed, palpi often enlarged and elongated. Labellum longer than the antennae, strongly flattened dorsoventrally and at least as wide as the facial swelling (except in *anthracinus* which has well developed palpi) 7

6. Stigma dark brown. Face pilose to above the middle; sides of face narrower than the facial swelling ..... *georgianus* n. sp., p. 154

Stigma obsolete. Face bare, except on the extreme lower margin; sides of face wider than the facial swelling (fig. 5a) ..... *beameri* n. sp., p. 151

7. Mesonotum chiefly gray, with distinct brown vittae. Aristae short and thick, scarcely two times longer than the remainder of the antennae (fig. 1b) .... *alaskaensis* n. sp., p. 147

Mesonotum not vittate. Aristae long and slender, usually three or more times longer than rest of antennae 8

8. First antennal segment with numerous long, usually black, bristles. Palpi of male elongate and well developed, at least three-fourths as long as the face. Palpi of female about one-third longer than the combined lengths of the three antennal segments, and noticeably swollen 9

First antennal segment bare or with only pale fine hairs in *arctiventris* James and *humilis* Loew. Palpi small, not developed, about one-half or less the length of the face and usually not longer than the antennae minus the aristae 18

9. Vestiture of face and pali black 10

Vestiture of face and palpi white 13

10. First antennal segment densely bristled above and below; noticeably enlarged, one and one-half to two times longer than the second segment and broader than the third 11

First segment bristled only on the under side; on the inner margin it is not more than half as long as the second segment and not at all swollen 12

11. Tomentum of femora and pile of abdomen pale. Third antennal segment small, nearly as wide as long and about equal in length to the second segment (fig. 14a). Palpi long and slender, about equal in length to the face. (Males run here). ..... *tomentosus* Bigot, p. 162

Tomentum of femora of both sexes and pile of abdomen of the the male black. Third antennal segment elongate oval in shape, two times longer than the second segment (fig. 10a). Palpi thick, swollen, about three-fourths as long as the face. (Both sexes run here.) ..... *proximus* (Walker), p. 161

12. Eyes of male distinctly separated on the front. Palpi as long as the face, reaching to bases of antennae. Upper portion of face conspicuously pilose. All pile of metapleura black ..... *luciferus* Adams, p. 159

Eyes of male joined, or very close together, on the front. Palpi about three-fourths as long as face, not reaching antennae. Upper portion of face very inconspicuously haired, with only a few short black hairs on inner margins near facial swelling. Metapleura with a dense clump of yellow pile on the upper portion ..... *anthracinus* Bigot, p. 149

13. First antennal segment densely covered with long bristles above and below (fig. 14a) 14

First antennal segment with short bristles only on the under side (fig. 8b) .... *kincaidi*, n. sp., p. 156

14. Females 15

Males 17

15. Femora and tibiae chiefly pale yellow 16

Legs brownish to black ..... *pilosus* Leonard

16. First antennal segment enlarged, about two times longer than the second ..... *tomentosus* Bigot, p. 162

First antennal segment shorter than the second from dorsal view ..... *longipalpis* n. sp., p. 157

17. Mesonotum and abdomen densely covered with long appressed silvery white hairs. First antennal segment noticeably longer than the others. Wings tinged with brownish. Palpi not over three-fourths as long as the face ..... *pilosus* Leonard

Mesonotum and abdomen with golden appressed pile. First antennal segment equal or smaller than the second. Wings hyaline. Palpi as long as the face ..... *longipalpis* n. sp., p. 157

18. Wings noticeably broad, rounded at the apices. Aristae conspicuously pubescent. A pale yellowish brown species ..... *rotundipennis* Loew

Wings normal in shape, not noticeably broad and rounded. Aristae bare or nearly so, with conspicuous pubesecnce only in *divisus* n. sp. Usually dark colored species 19

19. Femora chiefly black 20

Femora yellow 27

20. Face conspicuously haired on the sides, to the upper part of the facial swelling 25

Face bare above, or with but a few inconspicuous short hairs on sides near facial swelling 21

21. Eyes of male joined on the front 22

Eyes of male separated on the front approximately the width of one ocellus ..... *nudus* Cresson, p. 160

22. Face narrow, sides parallel; the width of the face in the middle is less than the width of one eye on a mid line (fig. 2b). The antennae are situated at the lower one-third of the eye height ..... *angustifacies* n. sp., p. 148

Face rather broad, sides tapering; width of face in middle about twice that of one eye. Antennae situated near middle of the eye height 23

23. Palpi and tegulae pale haired. First antennal segment with a clump of fine white hairs beneath ..... *arctiventris* James, p. 151

Palpi and tegulae densely black haired. First antennal segment without white hairs.. 24

24. Aristae bare. Pile of head and thorax black, except for the patch of yellow pile on the upper portion of the metapleura. Wings tinged with brown, stigma nearly concolorous with the membrane. First antennal segment with a few black bristles below. (Some specimens may run here.) ..... *anthracinus* Bigot, p. 149

Aristae noticeably pubescent. Pile of head and thorax chiefly pale. Wings hyaline, stigma dark brown. First antennal segment bare ..... *divisus* n. sp., p. 152

25. Eyes of male joined on the front. Stigma almost concolorous with the wing membrane. First antennal segment densely covered with long pale hairs ..... *humilis* Loew, p. 155

Eyes of male separated the width of the median ocellus. Stigma distinct. First antennal segment bare 26

26. Vestiture of palpi coarse black. Robust species; thorax, from wing base to wing base, as broad as its length, including the scutellum ..... *aldrichi* James, p. 148

Pile of palpi yellow. Thorax more slender, slightly longer than broad ..... *flavibarbis* Adams, p. 153

27. Abdomen, antennae and mouthparts black. Front of female one and one-half to two times as wide as one eye, from dorsal view 28

Abdomen in part yellow. Antennae and labellum yellow. Front of female about equal to the width of one eye 30

28. Females 29

Males ..... *testaceipes* Bigot, p. 161

29. Front very wide, over two times as wide as one eye. First antennal segment with a clump of white hairs below. Front femora usually darkened ..... *arctiventris* James, p. 151

Front about one and one-half times as wide as one eye. First antennal segment bare. All femora clear yellow ..... *testaceipes* Bigot, p. 161

30. Eyes of male angulate at lower part of front, just above antennae (fig. 15a). Face broad, sides almost parallel. In both sexes the pile of palpi is black and the coxae and scutellum are yellow ..... *xanthopus* n. sp., p. 163

Eyes of male not angulate. Face and front gradually narrowed above (fig. 13a). Pile of palpi pale. Coxae and scutellum dark brown to black ..... *modestus* Loew

31. Only apices of wings infuscated, veins R3, R4 and R5 broadly bordered with brownish ..... *fasciatus* var. *fasciatus* Leonard

Wings not as above 32

32. Only the extreme bases of the wings infuscated, wings otherwise hyaline ..... *basilaris* Say

Not as above 33

33. Wings smoky brown in color, usually darker along the anterior border and the veins 34

Wings not uniformly colored, clouded or spotted in various ways with brown or black 37

34. Mesonotum entirely velvety black 35

Mesonotum covered with dense golden tomentum 36

35. Abdomen entirely velvety black ..... *velutinus* Loew

Posterior lateral margins of abdominal terga one to five clothed with dense silvery tomentum ..... *connexus* Johnson

36. Abdomen entirely velvety black ..... *davisi* Johnson

Apices of abdominal terga, except for median interruptions, clothed with dense silvery or pale yellowish tomentum ..... *thoracicus* Fabricius

37. Wings hyaline except for a well defined subquadrate brown spot in the middle. This spot extends from the stigma through the discal cell ..... *quadratus* Say

Wings not so marked 38

38. Longitudinal veins and crossveins heavily bordered with brownish. Larger species, 7.5 mm. to 15.0 mm. in length 39

Longitudinal veins not bordered with brown. Wings with five small brown spots medianly, these occur on the crossveins and at the forks of the veins. Small species, 4.5 mm. to 6.0 mm. ..... *griffithi* Johnson

39. Wings with dark brown markings along the veins and crossveins. Species somewhat smaller in size, 7.5-11.0 mm. ..... *foedus* Loew

Wings faintly bordered with brownish along the veins and crossveins. Larger species, 9.0-15.0 mm. ..... *andersoni* Leonard

Chrysopilus alaskaensis n. sp.

Figs. 1a-c

This species is related to *flavibarbis* Adams and *aldrichi* James but differs strikingly from these species. It is readily distinguished by its fasciated mesonotum; light brown fumose wings; black pile; short arista; and its larger size.

Male.—Head: Compound eyes separated on the front about the width of the median ocellus. Front brownish gray, face gray pollinose. Lower three-fourths of face, palpi, occiput, vertex and ocellar triangle thickly black pilose. Sides of face tapering toward the front, being much narrower at the antennae than at mouth parts. First antennal segment bare and about half as long as the second. The second segment has some short black hairs and is equal in size to the third. The arista is very short compared to other *Chrysopilus* known to the writer. It is just two times as long as the three antennal segments and is finely pubescent (fig. 1b). Palpi rather well developed, extending half the length of the face. *Thorax:* Black in ground color and brownish gray pollinose. Mesonotum rather thickly covered with long, erect, black hairs. Mesonotum distinctly vittate, very similar in appearance to that of *Ptiolina majuscula* Loew. Two median brown vittae extend from the anterior margin of the mesonotum to just beyond the wing base; these are separated by a narrow gray stripe down the middle. The sides of the mesonotum have two brown spots, these are set off by the gray pollen along the transverse suture, lateral and posterior margins of the mesonotum and by the gray between the spots and the median vittae. Scutellum gray, thickly black pilose. Halteres with brownish black knobs and yellowish stems. *Legs:* Coxae and trochanters reddish brown to blackish, covered with rather long black pile and no trace of tomentum. Tibiae yellowish, tarsi brown. *Wings:* Brown fumose, stigma but slightly darker than the membrane. Tegulae densely black haired. Costa with an abundance of rather long black hairs near wing base. Stigma elongate, four to five times longer than wide. Cell R2 rather narrow, it is about the same width at the stigma as at the fork of R3 and R4 + R5; this cell is not broadened at stigmal area as in most *Chrysopilus*. Vein R4 ends well before the wing apex and the fifth section of the costa (between tips of veins R3 and R4) is approximately three times as long as the sixth section (between R4 and R5). Basal section of vein M2 one-third to slightly over half as long as the m crossvein. Basal section of vein M4 and the petiole of the cubital cell about equal in length to the m-cu crossvein. *Abdomen:* Rather densely gray pollinose and thickly black pilose, all pile erect. *Genitalia:* The eighth tergum is concave on both the posterior and anterior margins. Ninth tergum two times as wide as long, concave on the anterior margin and straight on the hind margin. Cerci elongate and slender (fig. 1c). Coxopodite one and one-half times wider than long. Harpagones rather slender, rounded at apices. Accessory structures of aedeagus extending slightly beyond the posterior edge of coxopodite (fig. 1a). *Length:* Body and wing, 6.5 mm.

Female.—The front is brownish gray pollinose with short black hairs. Front about two times as wide as one eye. Femora with a more reddish tinge than

in the males. Cerci round to oval in shape, very little longer than wide. Otherwise like the male except for genital characters. *Length:* Body, 7.0 mm.; wings, 7.8 mm.

Holotype: Healy, Alaska, June 24, 1921 (J. M. Aldrich). Allotype female and nine paratypes, five males and four females. Same data as type. Collected on June 23, 24 and 29, 1921.

Holotype, allotype and five paratypes returned to the U. S. National Museum. Two paratypes are in the Bishop Museum and two deposited in the Snow Entomological Collection.

CHRYSOPILUS ALDRICHI James

Chrysopilus aldrichi James, 1936, Journ. N. Y. Ento. Soc., 44: 343.

It is questionable that this is a distinct species. It is difficult to detect any appreciable differences in the width of the thorax in relation to its length in specimens of *aldrichi* and *flavibarbis* Adams. The writer has also observed considerable variation in the color of the pile on the palpi of some specimens of *flavibarbis*. It might be best to consider *aldrichi* a variety of *flavibarbis* but until more comparisons can be made the writer prefers to treat it as a species.

Type locality.—Tolland, Colorado.

Type in M. T. James' personal collection.

Specimens agreeing with *aldrichi* have been studied from the following localities: Long's Peak, Colorado, 9000 ft., July 13, 1926 (E. C. Van Dyke); Ute Creek, Colorado, 9000 ft., July 9, (R. W. Dawson); Platte Canyon, Colorado, June 10, 1927 (J. M. Aldrich); Estes Park, Colorado, July 10, 1936 (J. L. Sperry); Pingree Park, Colorado, July 9, 1938 (M. T. James); Yellowstone Park, Wyo., July 21, 1946 (G. F. Knowlton); Waterton Nat. Park, Canada, July 26, 1946 (G. F. Knowlton); Laketown, Utah, June 18, 1945 (G. F. Knowlton-S. L. Wood); Manti, Utah, June 25, 1946 (G. F. Knowlton); Amalga, Utah, May 30, 1944 (G. F. Knowlton); Daniel's Canyon, Utah, July 25, 1945 (G. F. Knowlton); Provo Canyon, Utah, July 26, 1945 (G. F. Knowlton); Logan, Utah, Aug. 1, 1938 (G. F. Knowlton-D. E. Hardy); Wellsville, Utah, July 7, 1938 (G. F. Knowlton); Eden, Utah, June 8, 1938 (G. F. Knowlton-D. E. Hardy); Washington, Utah, Aug. 8, 1938 (Knowlton-Stains); Providence, Utah, Aug. 11, 1938 (Knowlton-Hardy) and Franklin, Idaho, July 9, 1937 (C. F. Smith-F. C. Harmston).

Chrysopilus angustifacies n. sp.

Figs. 2a-c

This species is related to *C. arctiventris* James but differs strikingly. It is readily distinguished by the narrow parallel sided face; the position of the antennae; the black vestiture of the head and mouthparts; the lack of gray pollen on the body and the small round stigma of the wings.

Male.—Rather small, velvety brown to black species without gray pollen on the body. *Head:* All vestiture black. The eyes are joined for a distance comparable to two times the length of the ocellar triangle. In *arctiventris* this distance is equal to the length of the triangle. The compound eyes are very distinctly divided into an upper and a lower portion by a difference in the size of the facets; the division is at the lower one-third of the eye height, just oppo-

site the antennae. Front abruptly narrowed by the angulate inner margins of the compound eyes. Sides of face parallel, the face being approximately the same width at the antennae as at the mouthparts (fig. 2b). The face is very narrow compared to other species, being slightly less than the width of one eye on a mid-line. Face bare except on the extreme lower portion. Antennae small, first segment one-half as long as the second, and the second and third segments about equal in size. The second segment has a few short, inconspicuous black hairs on the apical portion and the third segment is covered with fine yellow hairs at its apex. The aristae are microscopically pubescent and are about three times longer than the antennae. The palpi are small and black, about equal in length to the three antennal segments. Palpi thickly covered with long black hairs. *Thorax:* brownish to black, almost devoid of pollen or pile, especially on the mesonotum and scutellum. There are a few recumbent yellow hairs and some erect black hairs on the dorsum. Knobs of halteres black, stems yellowish brown. *Legs:* Hind femora brown to black except for the yellow apices. Middle femora brown on basal halves and yellow apically. Front femora chiefly yellow, bases slightly brownish. Tibiae yellow, tarsi brownish. Legs very sparsely pilose, femora with some yellow pile. *Wings:* hyaline, stigma dark brown and almost round. Vein R3 curved markedly beneath stigma, cell R2 is two times as wide at the stigma as it is at the end of the subcostal vein. Fork of veins M1 and 2 situated well before the m-cu crossvein, making cell M1 sharply pointed at its base. Basal section of vein M2 is about equal to the m-cu crossvein in length. The petiole of the cubital cell is as long as the m-cu crossvein. *Abdomen:* brown to blackish sparsely covered with fine yellow pile. *Genitalia:* Ninth tergum about two times as wide as its greatest length, strongly concave on the anterior margin and nearly straight on the posterior margin (fig. 2c). Cerci about as long as wide, rounded apically. Harpagones rather slender, not strongly swollen medianly (fig. 2a). *Length:* body, 4.0-4.5 mm.; wing, 4.5-5.0 mm.

Female unknown.

Holotype male: Sunnyside Canyon, Huachuca Mts., Arizona, July 9, 1940 (D. E. Hardy). Five paratype males: four, same locality and date as type (L. J. Lipovsky) and one, Chiricahua Mts., Arizona, July 4, 1940 (D. E. Hardy).

The holotype and three paratypes have been returned to the Snow Entomological Museum at the University of Kansas. Two paratypes are in the Bishop Museum.

CHRYSOPILUS ANTHRACINUS Bigot

Figs. 3a-b

Chrysopila anthracina Bigot, 1887, Bul. Soc. Zool. France, 12: 105.

This species has not been definitely recognized since the original description and it was just recently, after Mr. J. E. Collin had kindly studied the type, that its status was clarified. The species is related to *luciferus* Adams, and the writer had considered these two synonymous until he restudied the Adams type in view of the information on *anthracinus* supplied by Collin. It is distinguished from Adams' species by the contiguous, or nearly so, eyes of the males; the shorter palpi; the less conspicuously pilose face and the all yellow

pile on the metapleura. The six specimens under *C. humilis* Loew in the Museum of Comparative Zoology which Osten Sacken* stated were not identifiable with *humilis* belong to *anthracinus*.

Male.—Head: Eyes joined for a very short distance on the front. The junction is less than the length of the ocellar triangle. Front and face brownish gray pollinose. Sides of face with a row of short black hairs extending on inner margins to the upper edge of the facial swelling. Lower portion of face, palpi, occiput and ocellar triangle covered with dense black pile. Face broad, on a median line it is over two times as wide as one eye. Face gradually tapering on upper portion. First antennal segment bare except for a row of moderately long black bristles at apex below. Second segment longer than the first and with a ring of short bristles at its apex. Third segment slightly longer than the second, rather oval in shape (fig. 3a), arista bare or with but microscopic pubescence. The arista is two and one-half times longer than the three antennal segments. Palpi rather well developed, about three-fourths as long as the face. Labellum rather narrow, about half as wide as the facial swelling and not flattened dorso-ventrally. *Thorax:* Black in ground color, lightly brownish pollinose above and densely brown on the sides. The dorsum and scutellum are chiefly yellow pilose with a few black hairs intermixed on sides and front margin of the mesonotum. The front margin of the mesopleurae are clothed with long intermixed black and yellow hairs. The metapleura are densely covered with long, bright yellow pile. The halteres are dark brown to blackish. *Legs:* Coxae, trochanters, femora and apical four subsegments of the tarsi yellow brown to blackish, tibiae and first subsegment yellowish, tinged with brown at apices. Front and middle coxae clothed with intermixed yellow and black pile, hind coxae with long yellow pile. Remainder of legs with yellow pile. *Wings:* Faintly but distinctly yellowish fumose, stigma pale, yellowish, scarcely differentiated from the membrane of the costal cell. Cell M1 sharply pointed at its base, vein M2 is straight for its entire length and the basal section is very slightly longer than the m crossvein. The petiole of the cubital cell is about half as long as the m-cu crossvein. *Abdomen:* Dark brown to blackish in ground color, densely covered with brownish pollen. Thickly pilose, the pile of the first four segments is predominantly yellow with a very few black hairs intermixed, that of the apical three segments and genitalia is chiefly black. *Genitalia:* The ninth tergum is two times wider than long and the posterior margin is gently convex. The harpagones are swollen at their middles and pointed at their apices (fig. 3b). They are densely haired above. *Length:* body, 5.0 mm.-5.5 mm.; wings, 4.6 mm.-5.0 mm.

Female unknown.

Type locality.—California.

Type in Collin collection, Newmarket, England. Mr. Collin kindly supplied information concerning the type.

The writer has seen the species from: Los Angeles, California (collected by Osten Sacken, Coquillett and by M. C. Van Duzee); Pine Valley, Cal., April 24, 1920 (E. P. Van Duzee); San Diego, Cal., April 6, 1915 (M. C. Van Duzee); Hackett

* 1877 Western Diptera, Bul. U. S. Geol. Surv., 3: 223.

Mdw. to Shotgun Creek, Sequoia Nat. Pk., Cal., July 25, 1915; Pullman, Wash., June, 1907 and Yakima, Wash., July 19, 1920 (A. T. Spuler).

CHRYSOPILUS ARCTIVENTRIS James

Chrysopilus arctiventris James, 1936, Journ. N. Y. Ento. Soc., 44: 343-344.

This species is closely related to *C. nudus* Cresson. It is distinguished by having the eyes of the male contiguous for at least a short distance on the front and by the presence of long white hairs on the underside of the first antennal segment (fig. 4a). The females fit into the *testaceipes* complex by having the femora yellow. They can be distinguished by the antennal pile and the very broad front; the front is over two times wider than one eye on a middle line. The front femora of the female are also slightly darkened. The front and vertex are sparsely covered with short black pile and lack the yellow pile and tomentum which characterize *testaceipes*.

James has adequately described the species, the writer needs only to add a few notes on the male genitalia. The harpagones are rather broad, moderately swollen medianly and rounded at apices. The eighth tergum is convex on its posterior margin. The ninth is about two times wider than long and is straight on hind margin. The cerci are rather quadrate in shape, slightly wider than long. *Length:* body, 6.0-7.0 mm.; wings, 4.5-5.0 mm.

Type locality.—Roggen, Colorado.

Type in M. T. James personal collection at Washington State College.

The writer has studied specimens from the following localities: Same as the type, May 29, 1937 (M. and H. James); Ft. Collins, Colo., July 6, 1902 (L. A. Titus); Ute Creek, Colo., July 11 (R. W. Dawson); Colo. Springs, Colo., Aug. (E. S. Tucker); Manitou Pk., Colo., July (F. H. Snow); Los Angeles, California, Apr. 29, 1915 (M. C. Van Duzee); Blue Lake, Cal., June 20, 1927 (Bradley); Jamez Springs, N. M., June 26, 1940 (R. H. Beamer); Ruidoso, N. M., June 26, 1940 (R. H. Beamer); Tajique, N. M., June 25, 1940 (L. J. Lipovsky); Near Lander, Wyo., July (Moodie); Kanarraville, Utah, June 20, 1940 (G. F. Knowlton), Medicine Hat, Alberta, June 22, 1940 (J. L. Carr); Wenass V., W. T., July 7, 1882; Erwin, S. D., June 1908 (J. M. Aldrich); Mantua, Utah, Aug. 5, 1936, (G. F. Knowlton-G. S. Stains) and Farmington, Utah, April 19, 1937 (D. E. Hardy).

Chrysopilus beameri n. sp.

Fig. 5a

This species is related to *angustifacies* n. sp. but is distinguished from all known species of *Chrysopilus*, except *georgianus* n. sp. by its rudimentary mouthparts. It is distinguished from this species by its bare face, obsolete stigma, smaller facial swelling, etc.

Male.—Small brown to black, scantily haired species. *Head:* Eyes joined for one and one-half times the length of the ocellar triangle. Eyes divided into two portions by a marked difference in the size of the facets on the lower one-third. Face and front brownish pollinose. Face gradually tapering above; just below antennae the face is about one and one-half times wider than one eye, on a mid line. The facial swelling is small compared to the sides of the face,

the sides are wider than the swelling (fig. 5a). First antennal segment shorter than the second, second slightly broader than the third but equal to it in length. Second segment with a few short, black hairs at apex above. Aristae pubescent, three times as long as the three antennal segments combined. Labellum very small and inconspicuous (fig. 5a), shorter in length than the antennae minus the aristae and less than half as wide as the facial swelling. Labellum bulb shaped, not flattened. Palpi very small, just slightly longer than the labellum and very densely black haired. All of the head pile black. *Thorax:* Dark brown pollinose, rather thinly covered with erect black pile in the middle of the dorsum, more thickly black pilose on the sides of mesonotum and on the propleura and upper portion of the mesopleura. Knobs of halteres brown, stems yellow. *Legs:* Femora brownish, with a slight tinge of yellow, on basal two-thirds to three-fourths becoming more yellow on apices. Tibiae yellowish brown, tarsi, chiefly brown. *Wings:* Hyaline, stigma faintly yellowed. Cell M1 pointed basally, base of vein M2 about three-fourths as long as the m crossvein. Cubital cell with a very long petiole, the petiole is equal or longer than the m-cu crossvein. *Abdomen:* Black in ground color and brown pollinose. First tergum chiefly pale pilose, the rest of abdomen covered with a moderate amount of black pile. *Genitalia:* The ninth tergum is wider than long, its posterior margin is straight. The cerci are nearly two times as wide as long. The harpagones are slender, not strongly swollen medianly and are rounded apically. *Length:* body, 3.7 mm.; wings, 4.0 mm.

Female.—Front and face brown pollinose, sides parallel. Front broad, it is two times as wide as one eye. The wing veins are very pale and the abdomen has some yellowish pile intermixed with the black. Otherwise like the male, except for genital characters. *Length:* body 3.3-3.6 mm.; wings, 3.4-3.8 mm.

Holotype male: Okefenokee Swamp, Georgia, July 27, 1939 (A. T. Hardy). Allotype female, Hillard, Florida, August 6, 1939 (R. H. Beamer). Twenty-three paratypes, fifteen males, eight females; two, same locality and date as holotype (D. E. Hardy); two, Billy's Island, Okefenokee Swamp, June, 1912, (Cornell Exped.); eight, same locality and date as allotype (R. H. Beamer, L. E. Tuthill); four, Lacoochee, Florida, Aug. 9, 1939 (D. E. Hardy, A. T. Hardy); one, Wakullah, Florida, July 10, 1939 (R. H. Beamer); two, Zolfo Springs, Florida, July 15, 1939 (R. H. Beamer, A. T. Hardy); one, DeLand, Florida, Aug. 8, 1939 (D. E. Hardy); one, Suwanee Springs, Fla., Aug. 2, 1939, (A. T. Hardy); one from Tifton, Georgia, Aug. 11, 1939 (R. H. Beamer) and one, Moorestown, N. J., July 12, 1927.

The holotype, allotype and eleven paratypes are in the Snow Ento. Coll. at the University of Kansas; two are in the Cornell University collection; two are in the National Museum collection; two in the American Museum collection and six are in the Bishop Museum.

Chrysopilus divisus n. sp.

Fig. 6a-b

This species is related to *C. arctiventris* James. It is distinguished by the pale first antennal segment; black haired palpi; the dense clump of black hairs on each tegula; the pubescent aristae; the black hairs at the base of the transverse suture and by genital characters.

Male.—Head: Lower face and occiput pale haired, ocellar triangle and palpi black haired. Eyes joined for a distance equal to the length of the ocellar triangle. Front brownish gray pollinose, face gray. Sides of face gradually tapering, just below the antennae the face is about one and three-fourths times wider than one eye, on a mid line. The first antennal segment is about one-half as long as the second and completely bare. The second segment is slightly swollen. It is wider and a little longer than the small third segment and has an apical ring of short black hairs. Aristae with moderately long, conspicuous pubescence. Palpi rather well developed, extending about half the length of the face. *Thorax:* Black in ground color, densely gray pollinose on the sides and brownish gray on the dorsum. Mesonotum with sparse recumbent pale pile and some erect black hairs. Sides of mesonotum with four or more long black hairs just above the base of the transverse suture. Scutellum grayish brown with rather dense recumbent yellow pile on the disk and long black hairs on the margin. Knobs of halteres black, stems yellow. *Legs:* Coxae, trochanters and femora black, covered with long yellow pile; femora with white tomentum above, tibiae chiefly yellow, with erect short hairs along dorsal surface. Tarsi brown. *Wings:* Tegulae very thickly black haired. Wings faintly yellowish, stigma dark brown and elongate. Basal section of vein M2 about half as long as the m crossvein. Basal section of M4 is half as long as the m-cu crossvein. The petiole of the cubital cell is equal to the length of the m-cu crossvein. *Abdomen:* Black in ground color, rather densely covered with grayish brown pollen. Pile pale, the dorsal surface is rather thickly covered with recumbent pile; on the lateral margins the hairs are long and erect. *Genitalia:* The eighth tergum is broadly 'V' shaped on the anterior margin, the concavity extends about one-third the length of the sclerite. Posterior margin of eighth tergum undulated, with a flat topped mound in the middle (fig. 6b). The ninth tergum is two times as wide as long, the anterior margin is concave and the posterior margin straight. The cerci are two times as wide as long and their hind margins are slightly serrate. The cleft of the coxopodite extends four-fifths the length of the segment. The harpagones are large and swollen, the tips are nearly square (fig. 6a). *Length:* body, 7.0 mm.; wing, 6.5 mm.

Female unknown.

Holotype male: Ruby, Arizona, July 13, 1940 (R. H. Beamer).

Type in the Snow Entomological Collection at the University of Kansas.

CHRYSOPILUS FLAVIBARBIS Adams

Chrysopila flavibarbis Adams, 1904, Kans. Univ. Sci. Bul., 2: 438.

Chrysopila cameroni Curran, 1926, Can. Ento., 58: 170. New synonymy based upon a study of a series of specimens from the Canadian National collection.

The species has been adequately described by Adams and by Leonard.* As is noted under the previous discussion of *C. aldrichi* James, *flavibarbis* is distinguished from James' species by its somewhat more slender thorax and the yellow pile of the palpi.

* 1930, Mem. Amer. Ento. Soc., 7: 141-142.

Type locality.—Bailey, Colorado, Aug., 1890.

Type in the Snow Entomological Museum at the Univ. of Kansas.

The writer studied the type series in the Snow collection and designated a male specimen from Bailey, Colo., as the Lectotype.

This species is rather common throughout Western United States and has also been seen from New England. The writer has seen specimens from numerous localities in the following states and Canadian Provinces: Alberta, British Columbia, California, Colorado, Idaho, Manitoba, Massachusetts, Montana, New Mexico, Ontario, Oregon, Saskatchewan, Utah, Washington and Wyoming.

Chrysopilus georgianus n. sp.

This species is related to *beameri* n. sp. by having the labellum poorly developed. It is distinguished by its hairy face with the sides narrower than the facial swelling, and the dark brown stigma in the wing.

Male.—Head: Eyes joined for about two times the length of the ocellar triangle. Front black, face brown pollinose. Face black pilose on lower two-thirds, the pile extends to about opposite the top of the facial swelling. Face, just below antennae, about equal in width to one compound eye, on a mid line. Sides of face narrower than the width of the facial swelling. Labellum small and bulb shaped, about half as wide as the facial swelling and shorter than the antennae minus the aristae. Palpi very tiny and slender, covered with long black hairs. First antennal segment about one-half as long as the second. Second segment equal in length to, but slightly broader than, the third. Second segment with a few short black hairs apically. Aristae distinctly pubescent. *Thorax:* velvety black, with no indications of gray pollen. All pile black. Mesonotum with short sparse pile in the middle but rather thickly pilose on the sides. Propleura and upper margin of mesopleura thickly haired. Lower portion of sternopleura and the median hind margins of pteropleura with a few hairs. The scutellum is bare in the specimen at hand. Halteres yellow. *Legs:* Coxae and trochanters brown. Femora brown on basal three-fourths, yellow at apices. Tibiae and tarsi yellow brown to brown. *Wings:* Hyaline, stigma dark brown and square in shape and not filling the apical portion of cell R2. Cell M1 pointed at base, basal section of vein M2 is about three-fourths as long as the m crossvein. The basal section of vein M4 is one-half as long as the m-cu crossvein. The petiole of the cubital cell is three-fourths as long as the m-cu crossvein. *Abdomen:* Brownish black, black pilose except for pale pile on the first tergum. The genitalia have not been dissected. *Length:* body and wings 4.2 mm.

Female unknown.

Holotype male: Perry, Georgia, Aug. 12, 1939 (D. E. Hardy).

Type in the Snow Entomological Collection at the University of Kansas.

CHRYSOPILUS HUMILIS Loew

Fig. 7a

Chrysopila humilis Loew, 1874. Berl. Ent. Zeits., 18: 379.

This species has not been well defined and it has not been identifiable from the previous descriptions. It has been allied to *C. nudus* Cresson and distinguished by having the wings tinged with brown or gray. This character appears to vary considerably and cannot be relied upon unless supported by other characters. The writer has studied the specimens collected by Osten Sacken that were under *humilis* in the Cambridge Museum of Comparative Zoology Collection and Dr. Bequaert has checked diagnostic characters on the type. Two specimens in this series are apparently the same as the type and six specimens belong to *anthracinus* Bigot. The specimens which agreed with the type of *humilis* are more closely related to *flavibarbis* Ad. and *aldrichi* James but are distinguished from these by having the eyes of the male contiguous on the front, the wings brownish fumose, the stigma almost concolorous with the membrane: the base of vein M2 not over one-half as long as the m crossvein; the first antennal segment has some long hairs and the third segment is much more elongate.

Male.—Head: All pile pale, whitish yellow. Eyes joined on the front for the length of the ocellar triangle. Front brownish, face gray pollinose. Face rather thickly pilose, the pile extending to above the upper margin of the facial swelling. Sides of face almost parallel, the face width is almost the same just below the antennae as at the mouthparts. First segment of antennae with long pale hairs near apex. Second segment slightly longer than the first and almost devoid of pile. Third segment elongate, equal in length to the first two segments (fig. 7a). The palpi are short and thick and very densely yellow haired. *Thorax:* Brown to black, all pile yellowish. Mesonotum covered with dense yellow tomentum and scattered erect hairs. Scutellum with dense tomentum on the disk and long hairs on the margin. Knobs of halteres brown, stems yellowish. *Legs:* Coxae, trochanters and femora brown, posterior femora slightly blackish. Tibiae yellow, tarsi brownish yellow. Femora with some yellow pile and with rather dense whitish tomentum above. *Wings:* The specimens at hand have the wings lightly fumose and the stigma almost concolorous with the membrane. Vein R3 is gently curved into the costa beneath the stigma. Fork of veins M1 and 2 situated well before the m crossvein, the basal part of M2 is equal to the m crossvein in length. The petiole of the cubital cell is nearly as long as the m-cu crossvein. *Abdomen:* Brownish in ground color, densely covered with pale yellow pile. *Genitalia:* Ninth tergum about three times wider than long, the posterior margin is very gently convex, the anterior margin is moderately concave. The harpagones are rather slender, rounded at apices and are conspicuously yellow haired on their outer edges. *Length:* 5.0-5.5 mm.; wings 4.8-5.3 mm.

Female unknown.

Type locality.—San Francisco, California.

Type in the Museum of Comparative Zoology Collection.

The two specimens from the Osten Sacken series were labeled just Osten Sacken, no locality was given. They were, however, in a series with other California specimens taken by Osten Sacken and are no doubt from that state.

Besides the two above mentioned specimens the writer has identified this species from the following localities: Los Angeles, Calif., Apr. 29, 1915 (M. C. Van Duzee); Los Cerritos, Calif., Apr. 3, 1915 (M. C. Van Duzee) and Riverside, Calif., Apr. 12, 1936 (W. C. Reeves).

Chrysopilus kincaidi n. sp.

Figs. 8a-b

This species is related to *longipalpus* n. sp. but is readily distinguished by having the eyes of the male holoptic; the first antennal segment bristled only below; the shorter palpi; the chiefly yellow legs of the male and the larger size.

Male.—Head: Eyes joined for a distance about equal to the length of six facets. Facets of lower third of each eye smaller than those of the upper portion. Ocellar triangle very prominent and densely covered with long black bristles. First antennal segment scarcely over half as long as the second and with a clump of rather short dark hairs below. Second segment with an apical ring of short bristles. Third segment about as long as wide and covered with short yellow pile. Aristae only with sparse microscopic pubescence (fig. 8b). The face is shaped much as in *longipalpus* n. sp., the upper margins are gently sloped and the sides are almost parallel. The face is densely gray pollinose and has sparse pale pile on the sides extending nearly to the top of the facial swelling. Lower portion of face and occiput densely covered with yellow white pile. Palpi about three-fourths as long as the face and covered with yellow white bristles. *Thorax:* Opaque brownish to blackish in ground color, covered with grayish brown pollen on the dorsum, gray on the sides. All bristles and pile pale, whitish on the sides and golden yellow on the dorsum; mesonotum and scutellum densely covered with tomentose pile. Stems of halteres yellow, knobs brown. *Legs:* Femora, tibiae and first subsegment of tarsi yellow. Coxae, trochanters and apical subsegments of tarsi yellow brown. Tibial spurs bright yellow. Basitarsi of hind legs nearly one and one-half times longer than the combined length of the other subsegments. *Wings:* Tegulae densely golden yellow pilose. Wings hyaline, stigmata yellow brown. Venation similar to that of *longipalpus* but with no appendix at the base of vein R4 and with the M1 more strongly bent upwards. *Abdomen:* Brown in ground color, densely covered with golden tomentum in unrubbed specimens, with sparse pale hairs along sides and some black hairs at apex. *Genitalia:* Ninth tergum gently convex on posterior margin, tergum one and one-third times wider than long. Coxopodite cleft almost two-thirds its length on posterior margin. Harpagones very broad, bluntly rounded at apices (fig. 8a). *Length:* body, 7.5 mm.; wings, 6.5 mm.

Female.—The front is two times wider than the width of one eye. Front brownish gray pollinose, with sparse black and yellow pile intermixed. Palpi thicker than in the male, slightly swollen apically. Palpi not quite so elongate

as in the male, they are about one and one-half times longer than the first three antennal segments and slightly less than three-fourths as long as the face. Mesonotum, scutellum and abdomen very densely golden tomentose in unrubbed specimens. Otherwise like the male, except for genital characters. *Length:* body, 7.5 mm.; wings, 7.4 mm.

Holotype male: Washington (Kincaid). Allotype female and two paratypes, one male and one female, same date as type with the numbers 72/93 on the labels. One paratype female, Altin, B. C. (E. M. Anderson).

Holotype, allotype and one paratype returned to the Illinois Natural History Survey. One paratype returned to Ohio State University and one retained in the Bishop Museum.

Chrysopilus longipalpus n. sp.

Figs. 9a-c

This species is most closely related to *tomentosus* Bigot. It is readily distinguished by its pilose face; small, more sparsely bristled, first antennal segment; white vestiture of head, palpi, pleura and legs; lack of black hairs on the mesonotum; hyaline wings and yellowish legs. It is separated from *flavibarbis* Adams by the elongate palpi and the strong hairs on the first antennal segment.

Male.—Entirely brownish to black species except for the yellow legs and brownish yellow halteres. *Head:* Eyes separated on the front, the front is equal to slightly wider than one ocellus. Front opaque, brownish black, grayish just above antennae. Front with a deep furrow in middle, extending from between the antennae to the beginning of the ocellar triangle. Ocellar triangle with very long, erect, black bristles on the posterior dorsal surface, some of these bristles are one-third longer than the length of the first three antennal segments combined. Head about two times as wide as long, from dorsal view. Occiput with a few short black hairs above, pile of the rest of occiput, lower part of face and palpi, long, dense and whitish. Upper portion of the face thinly whitish pilose, not so densely pilose as in *flavibarbis*. Occiput rather wide, its greatest width is about half that of a compound eye, from lateral view. Palpi very long and densely covered with long hairs, from a facial view the palpi and hairs almost completely hide the details of the face. The palpi are equal in length to the face from the labellum to the antennae (fig. 9c) and are about three times as long as the three antennal segments combined. First segment of antennae about equal in size to the second and with a ring of strong black bristles at apex. Ventral portion of segment more thickly bristled. Second segment with an apical ring of short black bristles. Aristae rather thickened at bases, tapering from third segment. Aristae finely pubescent. *Thorax:* Opaque brownish black in ground color, faintly grayish pollinose. Mesonotum and scutellum densely covered with recumbent golden tomentum and with rather abundant fine yellow hairs on lateral margins. There are a few of these erect hairs on the median portion of the mesonotum, one or two black notopleural bristles are present on each side. Scutellum faintly gray pollinose, the hind margin bearing several long, slender, yellow hairs; some of the hairs are longer

than the scutellum. Tegulae yellow pilose. Halteres yellow-brown, the stems slightly paler than the knobs. Pleura and coxae gray pollinose, covered with long whitish pile. The rest of the leg segments are brownish yellow. The femora are white pilose below, the posterior pair are covered with scale-like tomentum above. This is thickest on the apical halves. Tibial spurs white, those of middle legs well developed, they are decidedly longer than the greatest width of the hind femora. *Wings:* Hyaline, stigmata distinct, brown in color and elongate; length of stigma about equal to that section of costa between the end of Sc and R1 + 2. Vein R1 + 2 and R3 end very close together, nearly closing cell R2 at its apex. Cell R2 broad at middle of stigma, two times wider at this point than it is opposite the end of Sc. Branch of R4 and R5 situated well before the end of vein R1 + 2. R4 with a small appendix at the point where the vein curves at a right angle to meet R5. Basal section of M2 short, one-half as long as the m crossvein. Cell M1 pointed at base. Cubital cell with a short petiole about equal to the length of the basal section of vein M4 (fig. 9a). *Abdomen:* Brownish with faint grayish pollen on the posterior margins of the segments. Pile yellow, that of dorsum recumbent, that of margins and venter erect. *Genitalia:* Coxopodite cleft about half its length. Aedeagus extending to the apex of the coxopodite. Eighth sternum longer than wide, the posterior margin straight or nearly so. Harpagones strongly swollen medianly and narrowed beak-like at apices. Each with a clump of strong hairs on the outer dorsal surface (fig. 9b). Ninth tergum slightly wider than long, posterior border gently convex, anterior border broadly 'V' shaped. Tenth sternum acutely pointed on inner margins. Cerci about two times as wide as long. *Length:* body and wings 5.0 mm.

Female.—Differs from the male by having the eyes broadly separated. The front is one and one-half times the width of one eye. Front grayish brown pollinose covered with sparse, short, yellow setae, with a few short black bristles above near vertex. Vertex with some whitish tomentum. Frontal groove extending just two-thirds of the distance from the antennae to the ocellar triangle. Bristles of antennae yellow. Palpi not so strongly developed as in males, about one-half longer than first three segments and slightly curved upward at their apices. Aristae short. Legs, except coxae, entirely yellow. Thorax and abdomen more grayish pollinose. The stigmata of the wings are paler, cell R2 not so narrowed in the wing margin. Some of the paratype females lack the appendix at the base of R4. The basal section of M1 is slightly over half the length of the m crossvein and the petiole of the cubital cell is shorter, about half the length of the m-cu crossvein.

Holotype male: Buckley, Washington, July 6, 1935 (R. H. Beamer). Allotype female, same data. Four paratypes: one female, same data as type; one male, Tacoma, Wash., June 16, 1917 (H. G. Dyar); one female, Mt. Home Canyon, S. Bernardino Mts., Calif., June 8, 1924 (J. M. Aldrich) and one male, Vancouver, B. C., July 19, 1901.

Holotype, allotype and one paratype have been returned to the Snow Entomological collection. One has been returned to the U. S. National Museum, one to the Ohio State University collection and one has been deposited in the Bishop Museum.

CHRYSOPILUS LUCIFERUS Adams

Figs. 10a-b

Chrysopila lucifera Adams, 1904. Kans. Univ. Sci. Bul., 2: 437.

This species has not been recognized since the original description. The writer has studied Adams' type series and has identified the species from numerous localities in the west and northwest. From information gathered in correspondences with Mr. Collin in England, it is quite apparent that two of the three specimens in the type series of *C. tomentosus* Bigot were the same as *luciferus* Adams. *C. luciferus* is closely related to *anthracinus* and was considered a synonym of that species until information on Bigot's type was obtained from Mr. Collin.

Male.—Head: Eyes separated on the front approximately the width of one ocellus. First and second antennal segments about equal in size, third segment slightly smaller than the second and rather cone shaped. First segment with long, black bristles below (fig. 10a). Second segment with short black hairs at apex. All pile of head black. Upper face bare, lower half with short hairs. Palpi elongate, as long as the face and more than two times as long as the antennae without the aristae. Palpi densely covered with long black hairs. *Thorax:* Opaque black in ground color rather densely gray pollinose. Median portion of mesonotum brownish gray, scutellum gray. Mesonotum and scutellum almost devoid of pile (probably rubbed off), with only scattered yellow hairs. All pile of metapleura black. Halteres brown, stems slightly yellowish. *Wings:* Lightly yellowish fumose, stigmata brown, very distinct. Base of vein M2 as long as the m crossvein. Cubital cell with a long petiole, the petiole is nearly as long as the m-cu crossvein. *Legs:* Femora black, tibiae and tarsi yellowish brown. Femora with whitish appressed tomentum above and with sparse black hairs below. Tibiae and tarsi clothed with very short, appressed pile. *Abdomen:* Brownish in ground color, faintly grayish pollinose. Pile sparse and chiefly pale. *Genitalia:* The harpagones are densely pilose above on upper side, strongly thickened medianly, with rather narrow beak-like apices (fig. 10b). The coxopodite is cleft about one-half its length, measured at its longest point. The anterior margin of the coxopodite has a broadly 'U' shaped concavity in the middle. Ninth tergum almost as long as wide. Cerci narrow, two to three times wider than long. *Length:* 5.0-5.5 mm.

Female.—The following description is based upon the cotype female in Adams' type series. This specimen is from Kern Co., California but it appears to belong with the males in the series from Washington territory. The palpi are slender but not so developed as in the male. The palpi extend approximately three-fourths the length of the face and are brownish pilose. The sides of the face are sparsely covered with short dark hairs. These extend to the upper portion of the facial swelling and are most abundant on the inner margins of the face. The facial swelling has a few short dark hairs on the upper edge. The front is brownish pollinose, covered with dense golden yellow pile and intermixed short black bristles. The front is about one and one-half times wider

than one eye. First antennal segment with long black hairs above as well as below. Otherwise like the male. *Length:* body and wing 5.5 mm.

Type locality.—Washington territory.*

Type in the Snow Entomological collection.

The writer has seen the species from numerous localities in Washington, Oregon, California, Wyoming, Montana, Utah, Idaho, Alberta and British Columbia.

CHRYSOPILUS NUDUS Cresson

Fig. 11a

Chrysopilus nudus Cresson, 1919, Proc. Acad. Nat. Sci. Phila., 1919: 176.

This species is structurally very close to *C. testaceipes* Bigot and is distinguished by the dichoptic eyes of the males and the chiefly black femora. Specific differences have not been seen in the male genitalia.

Cresson's original description suggests that the species is related to *flavibarbis* Adams and he also states that the palpi are "long and falciform." This has led to considerable confusion in placing this species. Its status was just recently cleared up when Dr. J. A. G. Rehn kindly studied a paratopotype male and supplied the needed information to the writer. The palpi are short, only about half as long as the face and slightly shorter than the antennae minus the aristae. The face is conspicuously haired only along the lower margin. Dr. Rehn also confirmed that the first antennal segment is bare.

The following additional notes will be useful in placing this species.

Male.—Head: Eyes separated on the front about as wide or wider than one ocellus. The pile of palpi, lower portion of face and occiput is pale yellowish white. The sides of the face are nearly parallel. *Thorax:* Mesonotum and scutellum with pale yellow tomentum and sparse, whitish, erect pile. *Legs:* Tibiae and bases of tarsi yellowish, legs otherwise black; femora with white tomentum and hairs. *Abdomen:* Grayish green pollinose, with rather abundant yellow tomentum. *Genitalia:* The eighth tergum is about three times wider than long, its hind margin is almost straight and its anterior margin is gently concave. The ninth tergum is moderately convex on its hind margin (fig. 11a). The coxopodite is cleft about three-fourths its length on the hind margin. The harpagones are moderately swollen in the middle and are rounded at apices. The harpagones are densely brown to black pilose on dorsal surfaces and bare on the ventral sides. *Length:* body, 5.0 mm.; wings, 5.5 mm.

Female.—The females sometimes have the hind femora pale and are otherwise similar to the males except for the sexual characters.

Type locality.—San Jacinto, California.

Type in the California Academy of Science collection.

The writer has identified the species from the following localities; Hemet Reservoir, San Jacinto Mts., Calif., May 22, 1939 (T. Aitken); Pine Valley, San Diego Co.,

* The writer designated a male cotype as the lectotype.

Cal., Apr. 24, '20 (E. P. Van Duzee); Lone Pine, Cal., July 28, 1940 (L. J. Lipovsky-D. E. Hardy); Portola, Cal., June 5, 1915 (M. C. Van Duzee); Los Angeles, Cal. (Coquillett); Victorville, Cal., Apr. 30, 1918 (J. C. Bradley); Compton, Cal., Apr. 15; Siberian Outpost, Tulare Co., Calif., July 31, 1915 and Mt. Rainier Nat. Park, Wn., Aug., 1917 (A. L. Melander).

CHRYSOPILUS PROXIMUS (Walker)

Fig. 12a

Leptis proxima Walker, 1848, List Dipt. Brit. Mus., 1, P. 214. *Leptis simillima* Walker, 1848, List Dipt. Brit. Mus., 1: 215. *Leptis propinqua* Walker, 1848, List Dipt., 1: 215.

This species is related to *tomentosus* Bigot and is distinguished by the shorter more swollen palpi, which are only about three-fourths as long as the face; by having the vestiture of the femora and abdomen black and the third antennal segment oval in shape, two times longer than the second segment (fig. 12a). Leonard's description of this species is entirely adequate.

There has apparently been considerable confusion in the naming of some of the Western collections of *Chrysopilus*. A large collection at the Utah State Agricultural College which has been determined as *C. proximus* proved to be mostly a mixture of *flavibarbis* Adams and *Aldrichi* James. Knowlton's reference to *proximus* in his "Seasonal occurrence of *Chryospilus proximus* (Walker)"* should actually refer to these species. The writer has not seen this species from the Western States and would question Leonard's records from Nevada and California.

Type locality.—Nova Scotia.

Type in British Museum.

The species is rather common throughout Eastern United States. It has been recorded from the following States and Canadian Provinces: Connecticut, Florida, Illinois, Massachusetts, Michigan, New Brunswick, New Hampshire, New Jersey, New York, North Carolina, Nova Scotia, Ohio, Ontario, Pennsylvania, Quebec, Rhode Island, South Dakota, Virginia and Wisconsin.

CHRYSOPILUS TESTACEIPES Bigot

Chrysopila testaceipes Bigot, 1887, Bul. Soc. Zool. France, 12: 105. *Chrysopila bella* Adams, 1904, Kans. Univ. Sci. Bull., 2: 438. New synonymy based upon a study Adams' type series in the Snow Entomological collection. A male specimen from California (Baron) was designated as the lectotype.

This species is related to *C. nudus* Cresson but differs by having the eyes of the male contiguous on the front and the femora of the legs of both sexes chiefly or entirely yellow.

Male.—Head: Face bare or nearly so above the oral margin, sometimes with a few inconspicuous hairs on the inner margins of the face near the facial

* 1947, Bull. Brook. Ent. Soc., 42: 50.

swelling. Sides of face nearly parallel from the lower margin of the eyes to the antennae. Face one and one-half times wider than one eye from direct facial view. Eyes joined on the front. Palpi small, not much longer than the antennae minus the aristae. First antennal segment bare, smaller in size than the second segment. Aristae very microscopically pubescent. *Thorax* and *Abdomen:* Brownish in ground color, densely covered with greenish gray to golden tomentum. *Legs:* Chiefly yellow, except for yellow brown coxae and brownish apical subsegments of tarsi. *Wings:* Almost hyaline, stigmata elongate and light brownish. *Genitalia:* The ninth tergum is about one and one-half times wider than long, is slightly convex on the posterior margin and concave on the anterior margin. Eighth tergum three times wider than long, very slightly convex on the hind margin. Harpagones rather slender, subacutely pointed at apices and thickly haired above. Cerci quadrate in shape, about as long as wide. *Length:* body, 6.0-7.0 mm.; wings, 5.0-6.0 mm.

Female.—Similar in most details to the male. Front about one and one-half times wider than one eye. Front rather thickly covered with golden tomentum. Hairs of the inner margins of the face more conspicuous than in the males.

Type locality.—Wash. Territory.

Type in the Collin collection, in England.

Specimens have been studied from many localities in the following states and Canadian Provinces: Alberta, British Columbia, California, Colorado, Idaho, Montana, Oregon, Utah and Washington. Leonard has also recorded it from New Mexico.

CHRYSOPILUS TOMENTOSUS Bigot

Fig. 14a

Chrysopilus tomentosa Bigot, 1887. Bull. Soc. Zool. France, 12: 104.

This is a rather common western species readily recognized by its enlarged, densely bristled first antennal segment (fig. 14a) and elongate, slender palpi. The female has not been described previously. Bigot's type series contains three male specimens (not both sexes as described by Bigot). Mr. J. E. Collin studied Bigot's material and states that two species are represented in the type series of *C. tomentosus,* one of which has an enlarged densely haired first antennal segment and two specimens with a small basal segment of antennae, haired chiefly beneath. The latter species is apparently the same as *luciferus* Adams.

Female. Head: First antennal segment not quite so large or as densely bristled as in the male. The bristles are shorter and there are a few yellow bristles intermixed with the black. The first segment is about two times longer than the second but is not noticeably swollen. The front is chiefly brownish gray, is one and one-half times wider than one eye. The front, vertex and upper occiput possess short, chiefly recumbent, pale to golden yellow pile. The bristles of the front are very short and black, those of the vertex are longer and have yellow bristles intermixed with the black. The hairs of the lower portion of occiput and face are yellow gray. The sides of the face have short yellow hairs

near the facial swelling, extending to about the upper part of the swelling. The palpi extend about three-fourths the length of the face and are covered with yellow bristles. *Thorax:* The mesonotum, scutellum and dorsum of abdomen are densely covered with golden yellow tomentum-like pile. Bristles of thorax yellow and black intermixed. Pile of pleura entirely pale yellow. Stems of halteres yellow, knobs brownish. *Legs:* Femora and tibiae yellow, the latter slightly brownish tinged. Coxae and trochanters black, tarsi brownish to black. Otherwise the females are similar to the males, except for genital characters. *Length:* body and wings, 5-6 mm.

Type locality.—Washington territory.

Type in the Collin collection in England.

The writer has seen this species from numerous localities throughout California, Oregon, Utah, Washington and Nevada. It appears to be very common over a wide area in the spring.

Chrysopilus xanthopus n. sp.

Figs. 15a-c

This species is related to *modestus* Loew. It is distinguished by the fumose wings, the elongate stigmata, brown apex of the subcostal cell, the yellow scutellum and coxae, the yellowish brown ground color of the thorax, the black haired palpi and parallel sided face. The species is also of larger size.

Male.—Head: Entirely pale haired except for black hairs on ocellar triangle. Eyes joined on the front for more than the length of the ocellar triangle. Front and face densely gray pollinose. Face devoid of pile except on the lower portion. Antennae yellow, first segment very small, about one-half as long as the second, second segment equal in length to the third and with an apical ring of short black hairs. Aristae very finely pubescent, three times as long as the rest of antennae. Labellum bright yellow, clothed with pale pile. Palpi small and inconspicuous, about equal in length to the three antennal segments. Palpi covered with short black hairs. The sides of the face are almost parallel, the face being approximately the same width at the antennae as at lower portion of the facial swelling. The face, at the antennae, is one and one-half times wider than one eye (measured on a mid line from direct facial view). Front abruptly narrowed above (fig. 15a). The face of *C. modestus* is gradually narrowed at the antennae, it is but little over half as wide as one eye, on a mid line (fig. 13a). *Thorax:* Chiefly yellowish in ground color, gray pollinose on the sides and brownish pollinose on the dorsum. Mesonotum faintly fasciated, with three narrow yellowish vittae setting off four darker brown stripes. The median brown stripe is divided by a very thin line down the middle and ends in a yellowish area one-third the distance from the posterior border of the mesonotum. Humeri, scutellum and margins of mesonotum yellow. Postnotum ridged longitudinally in the middle. Pile of thorax golden yellow, sparse on the dorsum. Knobs of halteres brown, stems yellow. *Legs:* Entirely yellow except for brownish tarsi. Femora with white tomentum above, very sparsely yellow pilose. *Wings:* Brownish fumose, darker on apical one-third. Stigma

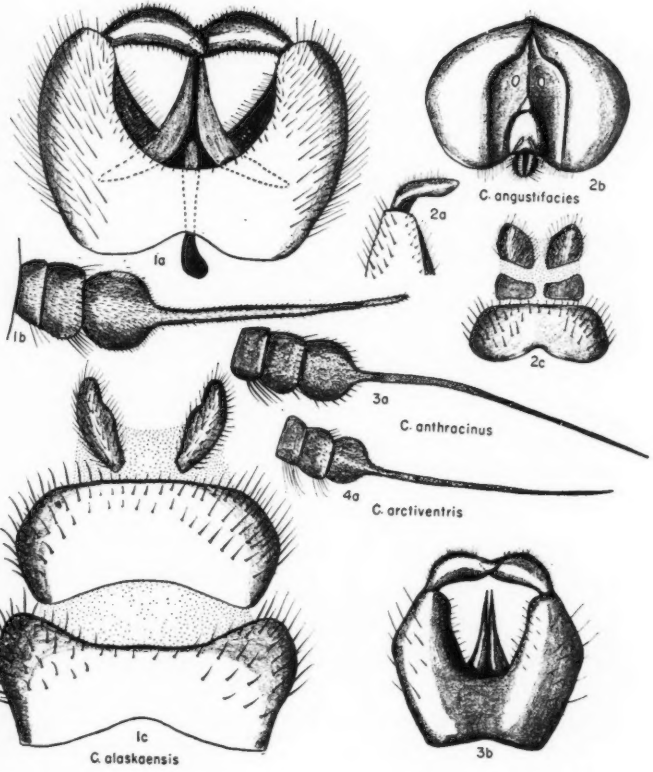
dark brown, elongate, four times as long as its greatest width. Apex of subcostal cell browned, almost concolorous with the stigma. Base of cell M1 pointed, basal section of vein M2 as long as or longer than the m crossvein. Forking of M1 and 2 situated opposite the forking of R4 and 5. Basal section of vein M4 equal in length to the r-m crossvein. Cubital cell with a rather long petiole. The petiole is equal to the length of the m-cu crossvein. *Abdomen:* First segment bright yellow, second chiefly yellow but sometimes with a median brown area on the tergum. The third tergum has a narrow basal band of yellow and a broad apical band, otherwise it is brown. The third sternum is entirely yellow. The fourth and fifth segments have narrow yellow bands apically, the rest of the abdomen is brown. *Genitalia:* The eighth tergum is undulated on its posterior margin (fig. 15c). In *modestus* the hind margin of the eighth tergum is almost straight. The ninth tergum is more than two times wider than its greatest length and is very slightly concave on the posterior border. The cerci are wider than long and very densely haired. Coxopodite cleft about one-half its length. Harpagones swollen on apical halves and each with a small beak-like apex. Dorsal surfaces of harpagones densely haired. Aedeagus extending not quite to apex of coxopodite (fig. 15b). *Length:* body, 7.0 mm.; wing, 6.8 mm.

Female.—Front brown pollinose, contrasting from the gray face. Front one and one-fourth times wider than one eye, sparsely covered with short black hairs. Vertex and upper occiput with rather long black hairs. Face not as wide in proportion to the eye width as in the male, equal to the width of the front. The abdomen is usually more yellowish than in the male, with the apical four to five segments often being entirely yellow. *Length:* body, 7.2 mm.; wing, 6.6 mm.

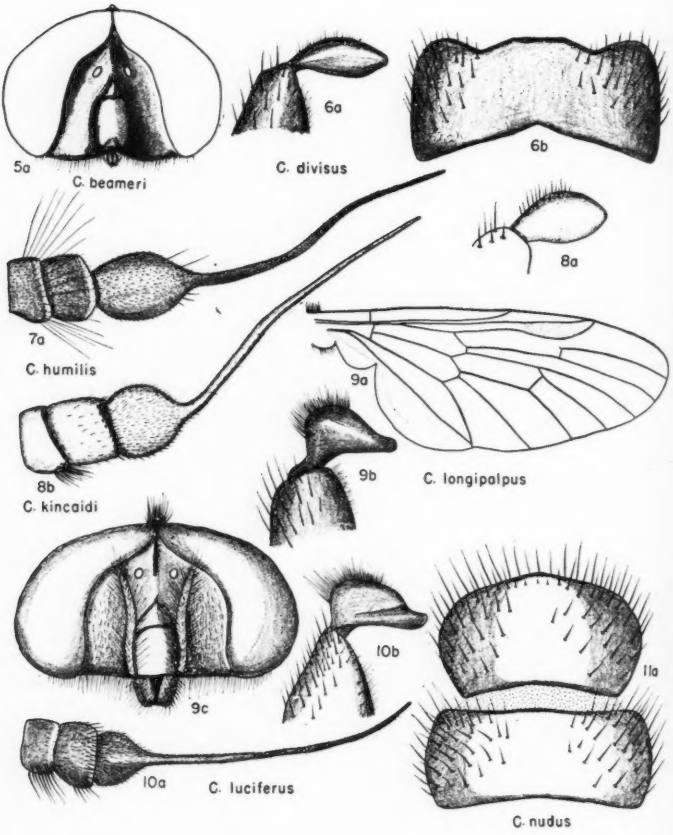
A male specimen from Cuernavaca, Mexico, Nov. 5, 1922 (E. G. Smyth) appears to belong to this species. The structural characters agree but the wing apex is more brown fumose, the crossveins are clouded with brown, the mesonotum more brownish in ground color and the mesonotum, scutellum and abdomen are densely covered with golden tomentum-like pile.

Holotype male: Sunnyside Canyon, Huachuca Mts., Ariz. VII-9-40 (L. J. Lipovsky). Allotype female, same locality and date as type (D. E. Hardy). Ten paratypes: two males and two females same locality and date as type (L. J. Lipovsky, D. E. Hardy, E. E. Kenaga); one male, Las Cruces, N. M. VII-3-40 (E. E. Kenaga); one female, Chiricahua Mts., Arizona VII-4-40 (D. E. Hardy); one female, Santa Rosa, N. M. VI-23-40 (D. E. Hardy); two males, Pinnaleno Mts., Ft. Grant, Arizona, July 17-18, 1917, Alt. 7000 ft. (R. C. Shannon) and one male, Gillespie Co., Texas, May 7, 1946 (D. J. and J. N. Knull).

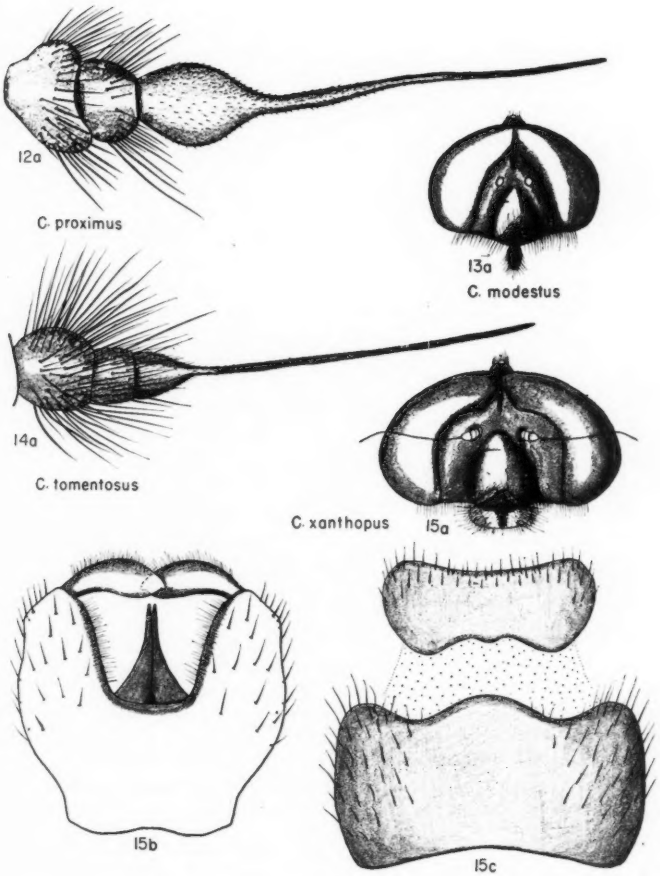
The holotype, allotype and four paratypes have been returned to the Snow Entomological collection at the University of Kansas, one paratype has been returned to Cornell University; one to Ohio State University; two have been presented to the U. S. National Museum and two are in the Bishop Museum. The Mexican specimen is in the National Museum collection.



Figs. 1-4.—*Chrysopilus alaskaensis* n. sp. (a) male genitalia, ventral view; (b) antenna; (c) male genitalia, dorsal view. 2. *C. angustifacies* n. sp. (a) male harpago, ventral view; (b) head of male, facial view; (c) male genitalia, dorsal view. 3. *C. anthracinus* Bigot. (a) antenna; (b) male genitalia, ventral view. 4. *C. arctiventris* James. (a) antenna.



Figs. 5-11.—5. *C. beameri* n. sp. (a) head of male, facial view. 6. *C. divisus* n. sp. (a) male harpago; (b) eighth tergum of male. 7. *C. humilis* Loew (a) antenna. 8. *C. kincaidi* n. sp. (a) harpago of male; (b) antenna. 9. *C. longipalpus* n. sp. (a) wing; (b) harpago of male; (c) head of male, facial view. 10. *C. luciferus* Adams. (a) antenna; (b) harpago of male. 11. *C. nudus* Cresson. (a) eighth and ninth terga of male.



Figs. 12-15.—12. *C. proximus* (Walker). (a) antenna. 13. *C. modestus* Loew. (a) male head, facial view. 14. *C. tomentosus* Bigot. (a) antenna. 15. *C. xanthopus* n. sp. (a) male head, facial view; (b) genitalia of male, ventral view; (c) eighth and ninth terga of male.

Notes on the Distribution of Michigan Mosquitoes (Diptera, Nematocera)

Carl B. Obrecht
Department of Biology,
University of Detroit, Detroit 21, Michigan

The following random collections are from several counties throughout the State of Michigan, taken during the spring and summer of 1947. The aim being to secure a basic, working collection of the State mosquito fauna for the University collections. There being very little published information regarding the distribution of Michigan mosquitoes, it was decded to make the results available. These notes are based on a series of 767 adults and larvae, representing a total of 68 collections from eleven counties. Most of the material, however, is from Cass, Genesee, and Wayne counties.

The majority of these specimens are adults taken while resting or biting. Larvae are few. With exceptions, the material is deposited at the University of Detroit.

Considerable mention is made of results of the 1944-45 mosquito surveys conducted by the Michigan Department of Health. C. E. Pederson, in his Masters' thesis, 1947, has recorded these extensive collections. This information has been included wherever pertinent. To my knowledge the complete results of this work have not appeared in print. During the summer of 1943, a joint survey was carried out by the Michigan Department of Health and Michigan State College. This work, covering the anopheline species of the southern counties in the State, is summarized by Sabrosky (1946). The "County Records" included with each species are, however, my own.

A considerable number of adults are females of the *A. stimulans, A. fitchii, A. excrucians* complex. These have been separated mainly on the basis of lower mesepimeral bristles, a character that does not seem to be entirely reliable Male terminalia were used whenever possible. Questionable material was chacked through the most kind cooperation of Dr. Alan Stone, of the United States Department of Agriculture, and Dr. Robert Matheson, of Cornell University. I am indebted to students, friends, and family for securing material and otherwise aiding in the work.

Anopheles punctipennis (Say).—The largest number were taken in resting and biting collections. A series of 15 adults were collected while biting on the shores of Birch Lake, Cass County, between 8:30 and 9:00 P.M. on August 20, 1947. One adult female was found resting in the kitchen of our house in Metropolitan Detroit. Larvae were taken only twice, two from a swamp near Fenton, and three from the Maple River, in Cheboygan County. In three of the five collections, they were found associated with *A. quadrimaculatus*. COUNTY RECORDS: Cass, Cheboygan, Genesee, Wayne.

Anopheles quadrimaculatus (Say).—This appears to be one of the most common mosquitoes biting during the evening hours. Local resort areas are particularly productive. A total of 128 specimens, mostly adults, were taken in 14 collections. On February 5, 1946, a single adult female was found resting in a Cass County residence. Hundreds of males and females of this species were discovered resting on the sheltered side of a recently occupied horse barn at Lake Fenton, Genesee County on September 20, 1947. This same day I sampled the marsh immediately behind the barn and found 13 *A. quadrimaculatus* larvae along with those of *A. punctipennis, U. sapphirina,* and a rather large population of *C. apicalis.* The marsh was nearly covered with *Lemna trisulca* but seemed to provide excellent rearing-grounds. Examination of the bog mat surrounding a small Genesee County lake on September 28, 1947, showed a large larval population of *A. quadrimaculatus, A. occidentalis,* and *U. sapphirina.* COUNTY RECORDS: Cass, Genesee.

Anopheles walkeri Theobald.—Seventeen specimens were taken in four night biting collections during July and August. The females are vigorous biters, and were collected with *A. vexans* in every instance. COUNTY RECORDS: Cass, Genesee, Wayne.

Anopheles occidentalis Dyar and Knab.—It appears that this form is most commonly found throughout the northern part of the State. The Michigan Department of Health surveys (Pederson, 1947) produced only a very few records from the southern half of the Lower Peninsula. Irwin (1941), however, records *A. maculipennis* from several southernmost counties in the State. It is possible these may prove to be *A. occidentalis,* which was not taxonomically understood at the time.

During the late evening, on August 7, 1947, I collected six females in the Pigeon River State Forest, Presque Isle County. September 28, 1947, I discovered the larvae, with those of *A. quadrimaculatus* and *U. sapphirina* in the margin of a bog lake in Genesee County. COUNTY RECORDS: Genesee, Presque Isle.

Aedes excrucians (Walker).—Adults of this species were usually associated with *A. fitchii, A. stimulans,* and *A. cinereus.* In 10 of the 12 adult collections they were taken with *A. fitchii.* The earliest date for the appearance of *A. excrucians* was May 5, 1947. At this time, a single fourth instar larva was found within the limits of the City of Detroit. A total of 50 adults were taken through the season, 49 of these in daytime biting collections. COUNTY RECORDS: Cheboygan, Chippewa, Genesee, Gogebic, Houghton, Ogemaw, Wayne.

Aedes fitchii (Felt and Young).—One of the most common mosquitoes in the State. Adults were taken in nearly 28 per cent of all collections, a frequency exceeded by only one species, *A. vexans. A. fitchii* was usually found biting during the daytime, along with *A. excrucians* and *A. stimulans,* although large numbers were found resting in sheltered places from May to July. Occasionally, *A. fitchii* will bite at night as shown by a collection taken in late evening of July 12, 1947. Larvae were collected from small

spring ponds in great abundance during early May. COUNTY RECORDS: Alger, Cass, Cheboygan, Chippewa, Genesee, Houghton, Wayne.

Aedes flavescens (Müller).—Previous records of this species in Michigan are relatively few. Irwin (1941) records specimens from Cheboygan, Ingham, and Kent Counties. Pederson (1947) reports a single male from Kent County, collected May, 1938.

May 24, 1947, I found one male in Genesee County, resting in a pile of dead leaves, sheltered by a cottage, along with *A. excrucians, A. riparius, A. fitchii,* and *A. stimulans.* No other specimens were obtained. COUNTY RECORDS: Genesee.

Aedes riparius Dyar and Knab.—Only one specimen was taken, in the collection with *A. flavescens.*

Irwin (1941) and Pederson (1947) have reported this species from a total of six counties, all in the northern part of the State. COUNTY RECORDS: Genesee.

Aedes stimulans (Walker).—Seemingly abundant in all parts of the State, *A. stimulans* was taken frequently in biting and resting collections along with *A. fitchii,* and *A. excrucians.* Although primarily a daytime biter, it was occasionally observed to bite well after dark. Adults were obtained from mid-May until mid-August. COUNTY RECORDS: Cheboygan, Genesee, Keweenaw, Wayne.

Aedes canadensis (Theobald).—Biting collections taken during the day in wooded areas were extremely productive. In few instances, the species did appear in the evening. *A. canadensis* is abundant, and was found in nine of the eleven counties studied, appearing most often with *A. vexans, A. cinereus, A. excrucians,* and *A. fitchii.* Large numbers of larvae were found in spring pools during May. COUNTY RECORDS: Alger, Cass, Cheboygan, Chippewa, Genesee, Gogebic, Keweenaw, Ogemaw, Wayne.

Aedes aurifer (Coquillett).—Six collections of 54 females were made at Lake Fenton, Michigan, from June 5 to July 18, 1947. The females are vicious biters and were usually encountered around wooded lakes and ponds. They generally associated with *A. fitchii, A. stimulans,* and *A. cinereus* in the biting swarm. Five were taken while biting in the late evening. One specimen, from Genesee County bore a definite atypical mesonotal pattern, similar to that of *A. thibaulti.*

Records of *A. aurifer* in Michigan are not many. It has been reported by Irwin (1941) from Cheboygan and Emmet Counties, and the Michigan Department of Health surveys (Pederson, 1947) added Keweenaw, Ontonagon, Marquette, Menominee, Chippewa, Bay, and Muskegon Counties. The species has also been reported from Michigan by Matheson (1924). COUNTY RECORDS: Genesee.

Aedes intrudens Dyar.—From reports of Irwin (1941) and Pederson (1947) this species seems to be fairly common throughout the State. I was

able to collect a single female, from a marsh in Genesee County. COUNTY RECORDS: Genesee.

Aedes sticticus (Meigen).—Seven adults and one larva were taken from stations widely scattered through the State. They were not numerous in any one locality. The Michigan Department of Health surveys (Pederson, 1947) collected over 1000 specimens from the State. This figure represented a sizeable percentage of their total collections. COUNTY RECORDS: Cheboygan, Genesee, Gogebic, Wayne.

Aedes triseriatus (Say).—This species was taken occasionally in biting collections both in the Lower and Upper Peninsulas of the State. Three larvae were taken July 19, 1947, from a hole in a small sapling in Genesee County. No larvae of other species were collected from this same hole. COUNTY RECORDS: Cass, Genesee, Gogebic, Wayne.

Aedes vexans (Meigen).—Of all the Culicines, this species appears to be the most abundant throughout the summer. It is represented in my collections by 114 adults and larvae in nearly 34 per cent of the collections. The first larvae were found on May 20, adults being active until September 30. A series of 53 resting males and females were collected with a net from a dense bed of *Apios* sp. in a woodlot near Fenton, on July 26, 1947. COUNTY RECORDS: Alger, Cass, Chippewa, Genesee, Wayne.

Aedes cinereus Meigen.—This small mosquito is a serious pest during the daylight hours in rural areas of the State. Like *A. aurifer*, it is a species frequenting woodlots and marshes. Its Michigan distribution is broad, being found in both Upper and Lower Peninsulas. All of the 1947 specimens were from biting collections, usually with *A. fitchii*, *A. excrucians*, and *A. stimulans*. Adults were active from June 5 to August 18. Larvae were not discovered. COUNTY RECORDS: Alger, Cheboygan, Chippewa, Genesee, Gogebic.

Culex apicalis Adams.—Records of *C. apicalis* are numerous from nearly all parts of the State. The Michigan Department of Health surveys (Pederson, 1947) collected 5,441 specimens during the summers of 1944 and 1945, far the greatest number of any Culicine species. During the summer of 1947 I obtained 13 adults and larvae in less than 9 per cent of the collections. COUNTY RECORDS: Alger, Genesee, Wayne.

Culex restuans Theobald.—Adults were found frequently in residential areas of Detroit. Two larval collections were made, one from a five-gallon chemical can of rust-stained water, the other from a ground-level tree hole containing about a liter of water. The Michigan Department of Health surveys (Pederson, 1947) collected a large series from the State. COUNTY RECORDS: Genesee, Wayne.

Culex salinarius Coquillett.—This mosquito is well distributed in the Lower Peninsula. As yet there have been no reports of its occurrence in the Upper Peninsula, although its known range extends to the Straits of Mackinac.

Adults appeared in four collections, one of which was from a well-populated Cass County resort, the other three from homes. One of the latter

specimens was discovered resting with *A. quadrimaculatus* in a house. *A. triseriatus* was taken in three of the four collections. COUNTY RECORDS: Cass, Wayne.

Culex erraticus (Dyar and Knab).—To my knowledge, there is no published record of this species having been found in the State. Pederson (1947), however, reports a single reared larva, collected by G. Ritchey, from Van Buren County in August, 1944. The specimen was identified by C. F. Gerlach. Matheson (1944) notes the range of this species as far north as "Illinois and Missouri". Ross (1947) records numerous collections far into northern Illinois. Dickinson (1944) and Irwin (1941, 1943) do not list the species from Wisconsin or Michigan.

Between 8:00 and 8:30 P.M., August 21, 1947, I was able to secure two female *C. erraticus* in a biting collection taken near Jones, Cass County. They appeared with *A. quadrimaculatus, A. walkeri, A. canadensis, A. vexans,* and *M. perturbans*. The specimens were checked by Dr. Stone. COUNTY RECORDS: Cass.

Culiseta mortisans (Theobald).—This species is widely distributed over the State. Irwin (1941) reports collections from Cheboygan, Emmett, and Washtenaw Counties. Pederson (1947) notes collections by Sabrosky in 1943 from Ionia and Kent Counties, and the Michigan Department of Health collections of 232 specimens from Dickinson and Menominee Counties in the Upper Peninsula, as well as numerous locations in the northern part of the Lower Peninsula.

My own collections include only a single male found in the bracken undergrowth of a mixed hardwood-conifer forest in Alger County, August 12, 1947. COUNTY RECORDS: Alger.

Psorophora ciliata (Fabricius).—Published records of *P. ciliata* in this State are few. Irwin (1941) has reported collections from Ingham, Kent, Livingston, and Wayne Counties. Pederson (1947) cites the original Michigan record of Pettit, in 1896, from Ingham County. Pederson also reports collections by Sabrosky, 1939 to 1942, from Oceana, Ottawa, Berrien, and St. Joseph Counties, and a collection from Jackson County by the Michigan Department of Health surveys.

During the summer of 1947 I collected five adults from Genesee and Cass Counties in August and September. One of these invaded our cottage at Lake Fenton. COUNTY RECORDS: Cass, Genesee.

Mansonia perturbans (Walker).—Inasmuch as Michigan, like most northern states, abounds in swampy breeding sites, *M. perturbans* is one of the more important pest mosquitoes. Fifty-three adults were found in 20 per cent of the collections. They appeared later in the summer, through July and September, most frequently with *A. quadrimaculatus* and *A. vexans*. COUNTY RECORDS: Alger, Cass, Chippewa, Genesee, Wayne.

Uranotaenia sapphirina (Osten Sacken).—Previous State records of this species are not many, but the unpublished results of the Michigan Department

of Health surveys (Pederson, 1947) show that *U. sapphirina* was found in three-fourths of the counties in the Lower Peninsula, and Houghton, Iron, Menominee, and Mackinac counties in the Upper Peninsula.

I found abundant larvae in typical Anopheline breeding sites of Genesee County during late September. One of these collections also contained larvae of *A. occidentalis*. COUNTY RECORDS: Genesee.

REFERENCES

DICKINSON, W. E. 1944—The mosquitoes of Wisconsin. Milwaukee Pub. Mus. Bul. 8(3): 269-365.

IRWIN, WILLIAM H. 1941—A preliminary list of the Culicidae of Michigan. Part I. Culicinae (Diptera). Entomol. News 52: 101-105.

———1943—The mosquitoes of three selected areas in Cheboygan County, Michigan. Papers, Mich. Acad. Sci. Arts and Letters 28: 379-396.

MATHESON, ROBERT 1924—The Culicidae of the Douglas Lake Region (Michigan). Canad. Ent. 56(12): 289-290.

———1944—Handbook of the mosquitoes of North America. Comstock Publishing Company, Inc., Ithaca, New York.

PEDERSON, CALVIN E. 1947—The distribution of Michigan mosquitoes. Masters' thesis (unpublished), Dep't. of Ent., Michigan State College.

ROSS, HERBERT H. 1947—The mosquitoes of Illinois. Ill. Nat. Hist. Surv. Bul. 24(1): 1-96.

SABROSKY, CURTIS W. 1946—The occurrence of malaria mosquitoes in southern Michigan. Tech. Bul. 202, Mich. State College Agr. Exp. Sta.

Second Supplement to the Flora of Mount Shasta

Wm. Bridge Cooke
1718 A Street, Pullman, Washington

Additions and Corrections

The occasional collections and observations of Mount Shasta plants during the summers of 1941, 1942, 1946 and 1947 indicate that there are still unreported species of plants to be found on the mountain.

Algae

Two collections of diatoms were made in 1940 near the source of Squaw Valley Creek in the running cold spring water. These were sent to Dr. Ruth Patrick by Dr. Francis Drouet. Her findings are as follows:

Collection 14711 (in order of abundance)

Cymbella ventricosa Kütz.
Navicula bacillum Ehr.
Odontidium hiemale var. *mesodon* (Ehr.) Grun.
Odontidium anceps Ehr.
Cymbella gracilis (Rabenh.) Cleve.

Collection 14712 (in order of abundance)

Ceratoneis arcus (Ehr.) Kütz .
Achnanthes lanceolata (Breb.) Grun.
Cymbella ventricosa Kütz.
Meridium circulare (Grev.) Ag.
Odontidium hiemale var. *mesodon* (Ehr.) Grun.

In a stagnant pool along Squaw Valley Creek at about 7500 ft. a collection of desmids was made. Dr. H. C. Bold determined this collection (15761) as follows:

Cosmarium ralfsii Bréb. and *Cylindrocystis brebissonii* Menegh.

Certain filamentous algae have been collected incidental to visits to moist habitats in search of other material. These have been determined by Dr. Francis Drouet as follows:

Microspora amoena (Kütz.) Rabenh.—In spring creek near Howard, 4000 ft.

Schizothrix muelleri Gom.—Among mosses in the Wagon Camp swamp, 5700 ft.

Stichococcus subtilis (Kütz.) Klerck.—In spring creek above Bear Springs meadows, 5000 ft.

Tribonema bombycinum (Ag.) Derb. & Sol.—In moist areas at the Sisson Southern Trail Spring, 6500 ft., and at the source of the water supply spring above Horse Camp, 8250 ft.

Zygnema sp. (sterile).—Near the source of Squaw Valley Creek in cold running water, 8500 ft.

Gloeocapsa violacea Kütz.—Material collected on seepage on basalt lava rocks at the Ice Cave below Widow Springs on the south side of the mountain was referred to this species by Dr. Drouet.

FERNS

In previous reports (4, 5) two species of *Botrychium* have been listed for the mountain. *B. lunaria* var. *minganense* was found in the Sisson Southern Trail Spring area (lower Shasta Fir Zone), one plant in each of two seasons. *B. pumicola* was found growing sparsely among lava on the south rim of Diller Canyon in the White Bark Pine Zone. The following record is based on a comparatively large colony, in contrast to the above records.

Botrychium simplex Hitchcock var. *compositum* (Milde) Lasch.—Found near the upper end of the meadows along the sources of Panther Creek in association with *Phyllodoce empetriformis, Mimulus primuloides, Polytrichum juniperinum, Castilleja miniata,* etc. The colony was only a few feet from the location at which Fig. 1, Plate 6 of the *Flora of Mount Shasta* (4) was taken. The habitat is there described. All specimens of *Botrychium* were determined by R. T. Clausen.

GYMOSPERMS

PINACEAE

Pinus contorta var. *murrayana* should be *Pinus contorta* var. *latifolia* Engelm.

ANGIOSPERMS

GRAMINEAE

Agrostis scabra Willd.—A small colony occurs in Incense Cedar woods at MacBride Springs. Determined by J. R. Swallen.

Festuca myuros L.—Occasional along the creek at MacBride Springs in ponderosa pine and incense cedar woods. Determined by J. R. Swallen.

Elymus glaucus var. *jepsonii* should be *Elymus glaucus* ssp. *jepsonii* (Davy) Gould (9).

Sitanion hansenii should be *Elymus hansenii* Scribn. (9).

Sitanion hystrix should be *Elymus elymoides* (Raf.) Swezey (9).

LILIACEAE

Calliprora scabra var. *analina* should be *Tritelia ixioides* (Ait. f.) Greene var. *analina* (Greene) Hoover.

Calochortus nudus var. *shastensis* should be *Calochortus nudus* Wats.

Smilacina amplexicaulis should be *Smilacina racemosa* (L) Desf. var. *amplexicaulis* (Nutt.) Wats. (8).

Tofieldia occidentalis should be *Tofieldia glutinosa* ssp. *occidentalis* (Wats.) Hitchc. (10).

ORCHIDACEAE

Spiranthes romanzoffiana C. & S.—One plant was found in the small meadow formed near the McCloud River Railroad fill along the overflow creek from the Mount Shasta city spring.

LORANTHACEAE

Arceuthobium americanum Nutt.—Frequent on branches, causing large witches' brooms, on *Pinus contorta* var. *latifolia* in the Military Pass area between Mt. Shasta and Black Crater (Whaleback Ridge) on the northeast side of the mountain.

CHENOPODIACEAE

Chenopodium botrys L.—Until 1940 this introduced weed remained below the crossing of the McCloud Railroad along the Shasta Snowline Highway. In 1941, however, it had advanced as far as MacBride Springs, 5 miles by road from the city of Mt. Shasta, and in 1947 it was found a half mile farther up the highway although still in the influence of the chaparral in the Sierra Mixed Conifer Zone.

Salsola kali var. *tenuifolia* G. F. W. Mey. Russian Thistle.—This weed, too, has advanced along the Shasta Snowline Highway since the opening of that road to general use in 1940. By 1941 it was found in the chaparral along the road as far up as 4500 ft., and in 1947 it was found along this road in chaparral and Sierra Mixed Conifer woods at 5500 ft.

PORTULACACEAE

Montia perfoliata should be *Claytonia perfoliata* Donn.

Montia perfoliata var. *depressa* should be *Claytonia perfoliata* var. *depressa* (Gray) v. Poellnitz.

Montia siberica should be *Claytonia siberica* L.

CARYOPHYLLACEAE

Sagina occidentalis and *S. linnaei* should be *Sagina saginoides* (L) Della Torre var. *hesperica* Fernald.

Silene menziesii should be *Silene menziesii* ssp. *typica* var. *viscosa* (Greene) Hitchc. & Maguire (11) and *Silene menziesii* ssp. *dorrii* (Kell.) Hitchc. & Maguire (11).

Silene watsonii should be *Silene sargentii* Wats. (11).

Stellaria media should be *Stellaria crispa* C. & S. which is found widespread in spring areas above 5700 ft. while *Stellaria borealis* has been found to date only at Wagon Camp.

CRUCIFERAE

Arabia platysperma Gray and var. *howellii* (Wats.) Jepson.—Dr. Reed Rollins is now of the opinion that both the species and variety occur on Mount Shasta. The species occurs in openings and woods in the Shasta Fir and lower White Bark Pine zones and is a large plant with elongated internodes

producing longer racemes of flowers than the variety which grows on exposed slopes in the White Bark Pine Zone, forms lower mats and is generally more stunted.

Descurainia pinnata (Walt.) Britt.—A colony of a variety or subspecies of this plant was found in sandy soil on the northeast side of the mountain near Andesite Station.

CRASSULACEAE

Sedum obtusatum should be *Sedum obtusatum* ssp. *boreale* R. T. Clausen (3). This subspecies was based on the previously reported colony to which Clausen was guided by the writer.

SAXIFRAGACEAE

Saxifraga nidifica Greene.—Several colonies of limited numbers of these plants occur around springs near the *Juncus balticus* var. *montanus* meadow along Squaw Valley Creek at the east base of Red Butte. It has also been obtained from seepage springs in the upper Squaw Valley Creek heather meadows. It is found only in the early part of the growing season.

LEGUMINOSAE

Melilotus alba Desr.—One plant was observed along the Shasta Snowline Highway above MacBride Springs in the chaparral at about 5000 ft. It was observed but not collected in 1941 and has not been observed since.

Astragalus purshii Dougl. var. *lectulus* (Wats.) Jones.—Reported by Barnaby (1) as having been collected on the "North slope of Mount Shasta" by Babcock and Stebbins, No. 1954.

Lathyrus graminifolia should be *Lathyrus lanszwertii* var. *aridus* (Bradsh.) Jeps.

CELASTRACEAE

Pachystima myrsinites should be *Paxistima myrtifolia* (Nutt.) Wheeler (15).

RHAMNACEAE

Ceanothus cordulatus should be *Ceanothus lorenzenii* (Jepson) McMinn (14). This species is a natural hybrid between *C. cordulatus* and *C. velutinus*.

HYPERICACEAE

Hypericum perforatum L. Klamath Weed.—A small colony had developed in the small meadow near a McCloud railroad fill near Howard by 1941. In 1947 it had spread up the mountain as far as the Mt. Shasta municipal spring and about 5500 feet along the Shasta Snowline Highway.

VIOLACEAE (det. by M. S. Baker)

Viola bakeri Greene.—This species occurs with *Viola purpurea* in Shasta Fir woods above Wagon Camp and in wet and dry meadows in the Wagon Camp area.

Viola purpurea var. *venosa* (Wats.) Brainerd.—This variety of the purple violet occurs at higher altitudes than the species. It is a dwarf plant which is found in open lava fields in the White Bark Pine Zone.

Viola blanda should be *Viola macloskeyi* Lloyd.

ONAGRACEAE (det. P. A. Munz)

Epilobium californicum Hausskn.—Occurs with other species of this genus in the Bear Springs meadows along the streams.

Gayophytum helleri Rydb.—This species was found in a large colony in the apparently dry bed of Horse Camp Creek at about 8250 ft.

Gayophytum lasiospermum Greene var. *hoffmannii* Munz.—Material of this variety has been found in open forests between 5000 and 8000 feet.

Gayophytum nuttallii T. & G. var. *typicum* Munz.—This, too, has been found in open forests between 5000 and 8000 feet on the southwest slopes of the mountain.

Gayophytum ramosissimum should be referred to the above two species and the name dropped from the list.

Godetia quadrivulnera should be *Clarkia rhomboidea* Dougl.

UMBELLIFERAE

Sanicula nevadensis Wats.—Occasional in woods just below Wagon Camp. Determined by L. Constance.

ERICACEAE

Pyrola secunda should be *Ramischia secunda* (L.) Garcke (6).

POLEMONIACEAE

Because of usage in certain herbaria and exchange collections based on determinations made by Dr. E. T. Wherry the following notes are added parenthetically. *Gilia aggregata*, as used in this series, is divided by Wherry into at least two categories: *G. texana* (Greene) Wood. & Standl. is used for material obtained along Mountainhouse Creek on the northeast side of Mount Shasta by Clausen and Trapido, and for material collected along the Sisson Southern Trail by the writer. Other colonies on the mountain may fall into other categories listed in Wherry's recent paper (16) such as material collected near MacBride Springs referred to *G. aggregata* ssp. *formosissima* (Greene) Wherry. *Phlox diffusa* ssp. *typica* Wherry is the name used by Wherry for specimens collected below Wagon Camp and at Horse Camp assigned to *Phlox douglassii* by Mason.

Gilia capillaris Kellogg.—A small colony occurred along the road between Wagon Camp and Bear Springs in spring areas. Determined by H. L. Mason.

SCROPHULARIACEAE (Det. F. W. Pennell)

Castilleja applegatei Fernald.—This occurs in the vicinity of MacBride Springs and along the road between Wagon Camp and Bear Springs in open woods and chaparral.

Mimulus jepsonii Grant.—This species occurs in sandy openings along the road between Wagon Camp and Bear Springs as well as at Sand Flats. It was earlier erroneously reported as *M. rubellus* and *M. rubellus* var. *breweri*.

Mimulus laxus Pennell.—This occurs along the creeks at Bear Springs.

Mimulus guttatus var. *puberulus* (Greene) Grant.—This species occurs in spring areas and along creeks at Wagon Camp.

Veronica wormskjoldii var. *alterniflora* (Fernald) Pennell.—Common in the South Gate Springs.

Castelleja arachnoidea should be *Castelleja arachnoidea* var. *shastensis* (Eastwood) Pennell (13).

Mimulus implexus should be *Mimulus tilingii* Greene.

Mimulus moschatus should be *Mimulus moniliformis* Greene.

Pentstemon procerus should be *Pentstemon shastensis* Keck.

Veronica serpyllifolia should be *Veronica serpyllifolia* var. *humifusa* (Dickson) Vahl.

OROBANCHACEAE

Boschniackia strobilacea should be *Kopsiopsis strobilacea* (Gray) G. Beck (2).

COMPOSITAE

Chrysothamnus viscidiflorus (Hook.) Nutt.—Frequent through one basin between lava ridges in the Lava Park area above Hotlum Station on the north side of the mountain. Determined by S. F. Blake.

Erigeron philadelphicus L.—Several plants have invaded the large meadow at Bear Springs. Determined by S. F. Blake.

Antennaria media Greene.—This occurs in large mats near the upper cascades of Squaw Valley Creek. Determined by S. F. Blake.

Antennaria rosea Greene.—Common along the lower part of Panther Creek below the meadows. Determined by S. F. Blake.

Arnica longifolia should be *Arnica longifolia* ssp. *myriadenia* (Piper) Maguire (12).

Erigeron compositus var. *multifidus* should be *Erigeron compositus* var. *glabratus* Macoun (7).

Introduced Plants

Of the plants found on the mountain to date there are 507 categories of vascular plants. Of these 3.16% are trees, 12.65% are shrubs, 84.19% are herbs. Of the total 6.91% are introduced species. The following notes will indicate something of the advance of these species in recent years.

Plants have been introduced into the area under study especially in the vicinity of places where temporary or permanent habitation or use has become established. In some areas which have been in use for a long period of time a large number of introduced plants occur. Other areas seem to have been used as long but only few introduced plants occur there. Areas of high elevation where the growing season is short have few introduced plants in spite

of the period of time during which they have been used. Recently graded roadways have become colonized with introduced species which are advancing up the mountain from the lowland habitats in which they had earlier become established.

The following discussion will be concerned first with the meadows and roadways of long established use in connection with lumber and sheep industries, second with the timberline mountain climbing base camp area, third with a new road and public camp ground, fourth with migration of native plants, and finally with some of the diseases of these introduced weeds.

Bear Springs, 5000 ft., is a small meadow bisected by Wagon Camp Road or McCloud Avenue. The springs which feed the several streams which flow through the meadow originate on a lava hillside. The area is a popular unimproved campsite for campers and hunters. Apparently near it at one time was a logging camp or a saw mill. Near it was, until recently, a sheep camp. In the meadows around the creeks a number of plants have become established including: *Agrostis alba, Amaranthus retroflexus, Barbarea orthoceras, Cerastium viscosum, Descurainia sophia, Erigeron philadelphicus, Phleum pratense, Plantago lanceolata, Poa pratensis, Rumex crispus, Trifolium pratense, T. repens* and *Verbascum thaspus*.

At Wagon Camp, 5700 ft., is a large grassy meadow in which some exotics have become established. This meadow was used as the base camp for the expedition led by C. Hart Merriam in 1896. Prior to that time it was a well known campsite; it may have been the location of at least one saw mill and of several sheep camps. One spring in the meadow area was the source of the water supply which was trucked to the construction crews on the Shasta Snowline Highway built between 1934 and 1939. Part of the meadow is now owned by a private organization which plans extensive developments. In this meadow only *Taraxacum officinale* has become well established; *Phleum pratense* occurs sparingly.

Along the road between Bear Springs and Wagon Camp several plants have become established in apparently dry places between a branch of the creek originating at Wagon Camp and the road. These include *Bromus mollis* and *Trifolium dubium*.

Along this road, but at lower elevations, between Bear Springs (5000 ft.) and Mount Shasta (3555 ft.) the road parallels the right-of-way of the McCloud River Railroad near Howard (4000 ft.), a small community owned by the railroad. The overflow from a large spring from which the city of Mount Shasta gets its water flows through a meadow near the railroad fill and in this meadow a colony of *Hypericum perforatum* had become established prior to 1940. By 1947 this species had ascended the mountain a few hundred feet to an old lane through both chaparral and woodland above the municipal spring where it did not occur in 1940. In 1947 this species was also observed along the Shasta Snowline Highway at about 5500 feet, a thousand feet above the second location. It had not been observed along this Highway before.

In 1938 one plant of *Cirsium lanceolatum* was found along the Wagon

Camp road between Bear Springs and Howard in the chaparral. In 1947 a number of individuals had reached an area along the Shasta Snowline Highway at between 5250 and 5500 feet. Possibly the seed source of the two colonies was different since the Wagon Camp road location did not have any representatives of this species in 1947.

Along the road above Howard near the McCloud River Railroad right-of-way *Marrubium vulgare* and *Chenopodium album* have been collected.

MacBride Springs, 5000 ft., is a recently improved public camp ground area located at the base of one of the Shastina lava flows. Few introduced plants have become established here. These occur only within irrigation range of the creek originating from the springs and include *Erodium cicutarium, Bromus tectorum, Erigeron canadense* and *Sisymbrium altissimum*. This is the highest point on the mountain at which *Bromus tectorum, Erigeron canadense* and *Sisymbrium altissimum* could be found in 1947.

For more than 85 years the principal route of access to the summit of Mt. Shasta from Berryvale, Sisson or Mount Shasta has been the Sisson Southern Trail and modifications thereof. Until recently this trail started from the end of a short road into the chaparral, went up through Cascade Gulch to Horse Camp and the summit. Along the lane leading to the foot of this trail, which was used by horses until 1939, *Erigeron canadense* has become established. *Tragopogon dubium* and *Camelina sativa* have also become established here in the lower chaparral.

Horse Camp (8000 ft.) has been used as a base for climbing the mountain for more than 60 years. Horses, which climbers used to ride to timberline, were tethered here while the ascent was made. Twenty-five years ago the Shasta Alpine Lodge were erected here. It was inevitable that some species would become established here, but there is no evidence of such introduction prior to 25 years ago. At that time water from a nearby spring was piped down to the Lodge and permitted to run continuously. Later the first custodian planted mixed grass seeds, in which some weed seeds had become mingled, in the wet area resulting from this overflow and a small meadow developed. The more hardy exotic grasses and herbs persisted along with some native plants although some of the natives seem to be crowding out the introduced plants.

In this meadow the most prominent grasses are *Agrostis alba, Poa pratensis* and *Phleum pratense*. Around the periphery of the meadow, which covers only about a hundred square feet, *Rumex acetosella* and *Malva rotundifolia* have been collected, although these species have not been found in the past few years. *Poa pratensis* is also found in moist places in the vicinity of the Shasta Alpine Lodge. *Trifolium repens* has been found occasionally in sod mats formed by this blue-grass. *Lepidium campestre* was found once in 1936 in the area occupied by the woodpile.

In addition to the above mentioned plants which bloom and occasionally fruit at this altitude, several plants have been observed which may bloom but which never fruit. In the small meadow a non-flowering species of *Cyperus* or *Scirpus* seems to be increasing vegetatively in the moister areas.

Near the stalls in the stable areas occasional sterile colonies of barley or oats occur following stabling of horses which are fed these grains. Two or three introduced shrubs of a decorative species of *Lonicera* are surviving at Horse Camp. They bloomed once in 1938. They retain a size of rarely more than a foot in height and about two feet in diameter.

In the period from 1934 to 1939 a road was broken through from Mount Shasta to Sand Flats (7000 ft.) and Panther Creek Meadows (7600 ft.), where a public camp ground was established. From 1937 to 1941 plants of *Chenopodium botrys* were observed along the lower mile of this road. By 1947 this species had reached 5500 feet, about 5 miles from Mount Shasta. *Salsola kali* var. *tenuifolia* followed the same pattern of rapid advance. However, *Sisymbrium altissimum* advanced only as far as MacBride Springs in about the same period of time.

Along this highway, earlier called the Everitt Memorial Highway, but now known as the Shasta Snowline Highway, at 5000 ft., about a half mile above MacBride Springs, one plant of *Melilotus alba* was observed in 1940. On a road cut at 4500 feet *Euphorbia crenulata* made a brief appearance in 1939 and now occurs in several colonies at another cut at 5500 feet.

Along an old road near Andesite Station on the north side of the mountain one colony of *Descurainia pinnata* was found in 1941.

Several native plants have increased their range in the past 10 years. *Euphorbia serpyllifolia* has spread along the edge of the Shasta Snowline Highway in the chaparral areas. A colony of *Pentstemon laetus* ssp. *sagittatus* has increased in size from a possible few individuals in 1936 to a large colony at the Wagon Camp road junction switchback on the Shasta Snowline Highway and scattered plants now occur along the road below the junction. *Chamaesaracha nana* and *Nama lobbii* have developed colonies at various points along the Highway in all zones through which the highway goes.

With the weeds which have come to Mount Shasta there are several diseases which have reached the mountain. *Cystopus candidus* has been found associated with *Sisymbrium altissimum* as far up the mountain as MacBride Springs. To 1947 it was found associated with no other host on the mountain.

At Horse Camp, on *Poa pratensis*, *Helminthosporium vagans* and *Puccinia rubigo-vera* have been observed to greater or less degree of severity in different seasons. *Erysiphe graminis* has occurred yearly on this host in Horse Camp seepage areas.

Ustilago bullata occurs regularly on scattered plants of *Bromus tectorum* in the chaparral along the old snowline highway.

Euphorbia crenulata and *E. serpyllifolia* have been found to be parasitized by *Uromyces proeminens* along the lower stretches of the Shasta Snowline Highway.

On *Hypericum perforatum* in the small meadow near Howard *Uromyces hyperici* was abundant in 1941.

Taraxacum officinale at Wagon Camp was host to two common fungi found on other hosts on the mountain. *Sphaerotheca humuli* var. *fuliginea*

and *Puccinia hieracii* have been found on occasional plants of this host.

It is possible that these hosts brought their parasitic fungi with them to the mountain. However, in the cases of *Puccinia rubigo-vera, Ustilago bullata, Puccinia hieracii* and *Sphaerotheca humuli* var. *fuliginea* native hosts on other parts of the mountain, or near the introduced plant, could well have been infected prior to the advent of the weeds since these are widespread diseases of groups of hosts. The other diseases are, so far as known, restricted to the hosts with which they have been introduced to the mountain.

REFERENCES

1. BARNEBY, R. C. 1947—Pugillus Astragalorum VII. Amer. Midl. Nat. 37: 510.
2. BECK, G. 1930—Pflanzenreich IV, Family 261.
3. CLAUSEN, R. T. 1942—Studies in the Crassulaceae. III. *Sedum*, subgenus *Gormania*, section *Eugormania*. Bull. Torr. Bot. Cl. 69: 27.
4. COOKE, W. B. 1940—Flora of Mount Shasta. Amer. Midl. Nat. 23: 497.
5. ———1941—First supplement to the flora of Mount Shasta. Ibid. 26: 74.
6. COPELAND, H. F. 1947—Observations on the Structure and Classification of the Pyroleae. Madrono 9: 65.
7. CRONQUIST, A. 1947—Revision of the North American species of *Erigeron* north of Mexico. Brittonia 6: 121.
8. GALWAY, D. H. 1945—The North American species of *Smilacina*. Amer. Midl. Nat. 33: 644.
9. GOULD, F. W. 1947—Nomenclatorial changes in *Elymus* with a key to the California species. Madrono 9: 120.
10. Hitchcock, C. L. 1944—The *Tofieldia glutinosa* complex of western North America. Amer. Midl. Nat. 31: 487.
11. HITCHCOCK, C. L. AND BASSETT MAGUIRE 1947.—A revision of the North American species of *Silene*. Univ. Wash. Publ. Biol. 13: 1-73.
12. MAGUIRE, B. 1943—A monograph of the genus *Arnica* (Senecioneae, Compositae). Brittonia 4: 386.
13. PENNELL, F. W. 1947—Some hitherto undescribed Scrophulariaceae of the Pacific States. Proc. Acad. Nat. Sci. Phila. 99: 155.
14. VAN RENSSELAER, M., AND H. E. MCMINN
15. WHEELER, L. C. 1943—History and Orthography of the Celastraceous genus "*Pachystima*" *Rafinesque*. Amer. Midl. Nat. 29: 792.
16. WHERRY, E. T. 1946—The *Gilia aggregata* group. Bull. Torr. Bot. Club 73: 194.

Embryological Studies in the Orchidaceae. I. Gametophytes

B. G. L. Swamy

Biological Laboratories, Harvard University, Cambridge 38, Mass.

CONTENTS

Introduction 184
Material and methods 184
Observations 185
Microsporogenesis and male gametophyte 185
Megasporogenesis and female gametophyte 189
Discussion 193
Anther 193
Ovule 195
Summary 199
Acknowledgement 200
References 200

I. Introduction

When one considers that out of more than 15,000 species of orchids, only about 175 species have so far been studied embryologically and even these very imperfectly, the need for further information on these plants is quite apparent. In India alone about 125 genera and 1500 species are recorded but only a few of these have been studied from the embryological standpoint (Seshagiriah, 1941; Swamy, 1941, 1942, 1943, 1944, 1945, 1946, 1947).

Scharf (1931) and Swamy (1943a) have given a brief review of the embryological investigations on orchids. Among the nineteenth century authors, the names of Muller, Hofmeister, Hildebrand, Pfitzer, Guignard, Strasburger and Treub figure prominently. Their work had already shown the variability of the female gametophyte and embryo in orchids. Work in the present century has brought to light some additional and interesting features concerning the development of the embryo sac, apomixis, polyembryony and endosperm formation. Although such investigations will be referred to here from time to time, a fuller review will be provided only in the concluding paper of this series.

II. Material and Methods

The present work embodies the results of my studies on the development of the gametophytes in the following species, material of which was collected from various localities in southern India.*

* The names of the different tribes, subtribes and species are arranged according to Pfitzer (1889).

Tribe Cypripedilinae
Paphiopedilum Druryi Pfitz.
Tribe Ophrydinae
Peristylus spiralis A. Rich.
P. stocksii Krzl.
Tribe Coelogyninae
Coelogyne breviscapa Lindl.
C. odorotissima Lindl.
Tribe Liparidinae
Oberonia iridiflora var. *denticulata* Hook.
Tribe Phajinae
Spathoglottis plicata Bl.
Tribe Cyrtopodiinae
Geodorum densiflorum Schlechter.
Eulophia nuda Lindl.
Tribe Dendrobinae
Dendrobium barbatulum Lindl,
D. haemoglossum Thw.
D. microbulbon A. Rich.
D. graminifolium Wt. Ic. t. 1649.
Tribe Bulbophyllinae
Bulbophyllum mysorense J. J. Smith.
B. neilgherrense Wt. Ic. t. 1681.
Tribe Sarcanthinae
Diplocentrum recurvum Lindl.
D. conjestrum Wt. Ic. t. 1681
Luisia teretrifolia Gaud.
L. tenuifolia Bl.
Cottonia macrostachyanum Wt. Ic. t. 1755.
Saccalobium filiforme Lindl.
S. Jerdonianum Reichb.
S. gracile Lindl.
S. pulchellum Fischer.
Vanda spathulata Spreng.
Aerides cylindricum Lindl.
A. ringens Fischer.
Rhynchostylis retusa Bl.

Of the fixatives tried, formalin-acetic-alcohol and Allen's modification of Bouin's fluid gave the best results. Heidenhain's iron alum hematoxylin in combination with light green or erythrosin was used for staining.

III. OBSERVATIONS

1. MICROSPOROGENESIS AND MALE GAMETOPHYTE

Structure of the microsporangium.—In general, the wall of the anther is made up of five layers: the epidermis, endothecium, middle layers and the tapetum (Fig. 1). In certain cases occasionally, however, there may be only a single middle layer so that the wall consists of four cell layers only (Fig. 2).

Tapetal cells remain uninucleate throughout and are of the secretory type (Fig. 2) in all the orchids. *Paphiopedilum Druryi,* however, is exceptional in that the cells become binucleate at the time the microspore mother cells are in synizesis (Fig. 1). This is important as there is no record of a binucleate tapetum in the family.

At maturity, the subepidermal layer develops the characteristic thickenings of the endothecium. In *Spathoglottis* (Fig. 3), some species of *Dendrobium* and *Vanda,* three to four layers of cells towards the stalk end of the anther also show thickenings similar to that of the endothecium.

Pollen mother cells.—The primary archesporium differentiates in the hypodermal layer. After cutting off the primary parietal layer, it increases in bulk by mitotic divisions to constitute the microspore mother cells. The increase in bulk is not associated with any special feature in the majority of orchids, where the mature pollen grains organize into pollinia. But in *Peristylus,* where the pollen grain tetrads are further agglutinated into small packets known as massulae, a noteworthy feature is recognized. In this genus, the pollen mother cells resulting from the division of each archesporial cell remain together as one small unit which retains its individuality and forms a massula (Figs. 4-9). The germination of pollen grains on the stigma is

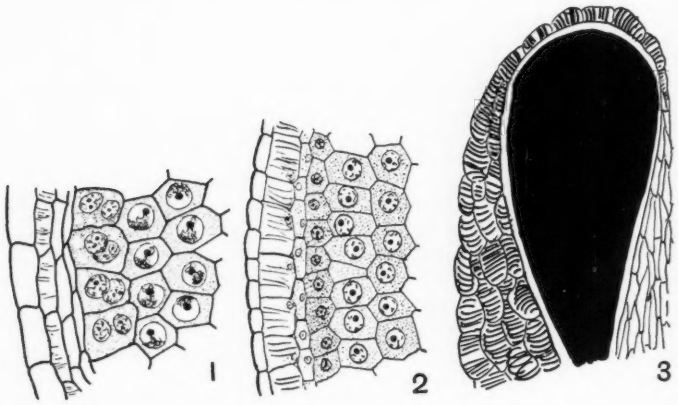
also accomplished in this *en masse* condition (Fig. 10). Thus the massulae pattern is blocked out at such an early stage when the microspore mother cells are differentiating.

Formation of pollen grains.—The sequences associated with the reduction divisions and the development of pollen grains tell a very uniform story in all the species studied at present irrespective of the diversities seen in their mature morphological form, i.e., single grains, compound grains, massulae, pollinia. The following account typifies the condition:

The reduction divisions are accomplished in a simultaneous manner. The resulting tetrads in the majority of instances conform to the isobilateral arrangement; less frequently a tetrahedral arrangement may also be the outcome. Cases showing a series of intermediate conditions between these fairly stabilized patterns, though uncommon, are not altogether wanting. Further, in some species belonging to the tribes Dendrobinae, Bulbophyllinae and Sarcanthinae, the tetrads disposed towards the periphery of the pollinia, not infrequently show a linear or T-shaped arrangement.

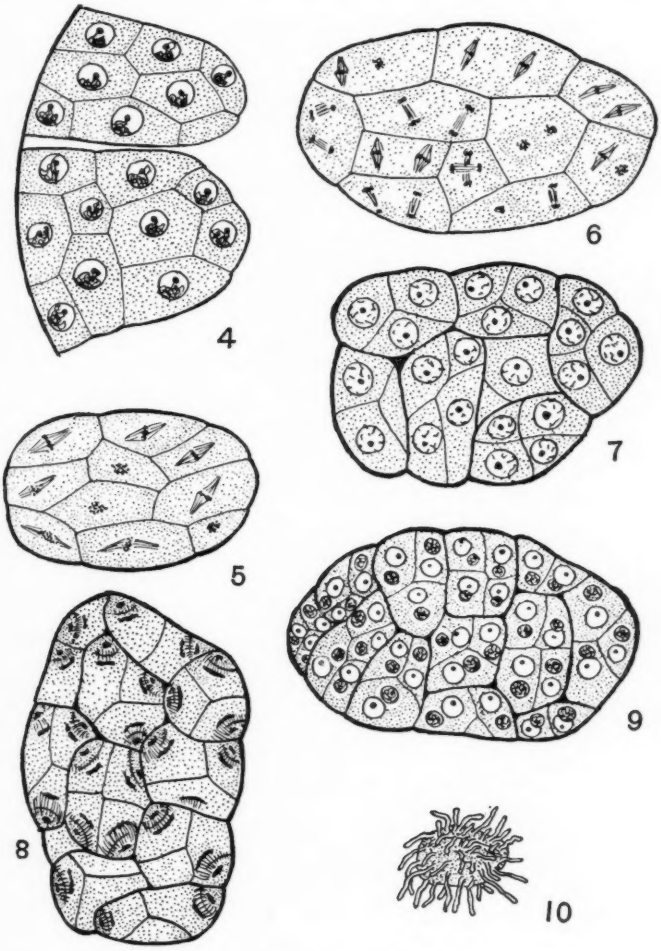
In *Paphiopedilum*, the individual uninucleate pollen grains separate out of the tetrad soon after the reduction divisions and become invested with a thick wall (Fig. 11). In others, however, the further development continues to take place in the *en masse* condition. This latter feature facilitates observations on the exact plane of division of the uninucleate microspore.

The nucleus of the freshly established microspore occupies a somewhat central position in the cell (Fig. 12). Before the next division, it moves



Figs. 1-3.—1. *Paphiopedilum Druyi*. A portion of young anther, showing the structure of the anther wall, binucleate tapetum and microspore mother cells in synizesis, ×457.1. 2. *Vanda spathulata*. The same, showing the structure of the anther wall, uninucleate tapentum and microspore mother cells in resting condition, ×457.1. 3. *Spathoglottis plicata*. Median longitudinal section of one half of an anther, showing multiple cell layers towards the stalk end exhibiting fibrous thickenings, ×78.4.

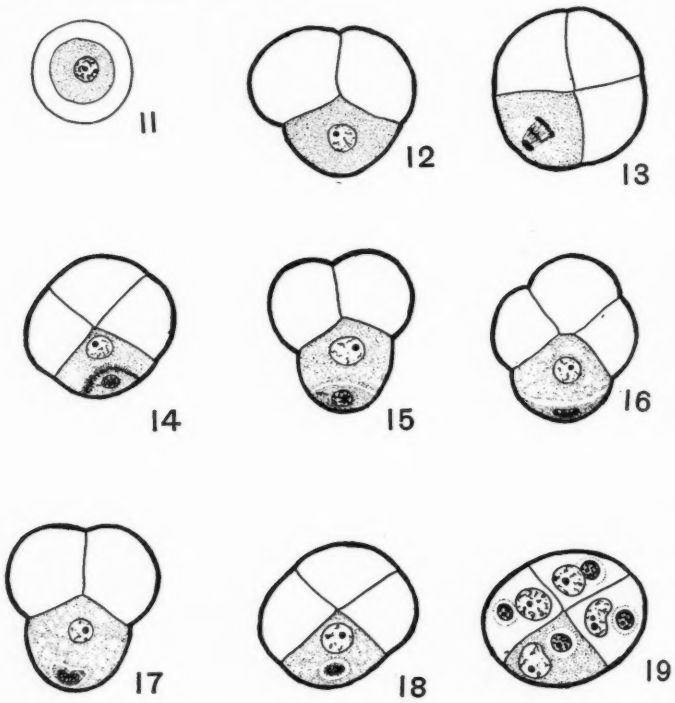
towards the outer side of the compound pollen grain and undergoes mitosis. The position of the spindle during this division is in such a manner that the generative cell is always cut off towards the exterior side of the tetrad (Figs. 13, 14). The generative cell is characteristically lens-shaped and always



Figs. 4-10. *Peristylus spiralis*.—4-9. Stages depicting the method of development of pollen grains in a massula condition. Further explanation in text, ×783.6. 10. Pollen tubes emerging from a massula, ×78.4.

smaller than the vegetative cell. Further, the former and its nucleus show greater avidity for stains than the contents of the vegetative cell.

A transitory wall is deposited between the vegetative and generative cells (Fig. 14). After a time, the wall disappears and its place may be discerned by a clear space (Fig. 15). The plasma of the vegetative cell enlarges to such an extent that the generative cell becomes adpressed against the inner face of the spore wall, so that for a time the generative cell appears like a crescent (Fig. 16). After this stage, the enlarging plasma of the vegetative cell may be seen making its way between the generative cell and its contacting spore wall (Fig. 17) and this process results in the complete inpushing of the generative cell back into the plasma of the vegetative cell (Fig. 18). Now the position occupied by the "inpushed" generative cell is not consistent in relation to the tetrad (Fig. 19). This two-celled condition of the pollen grains represents the shedding stage.



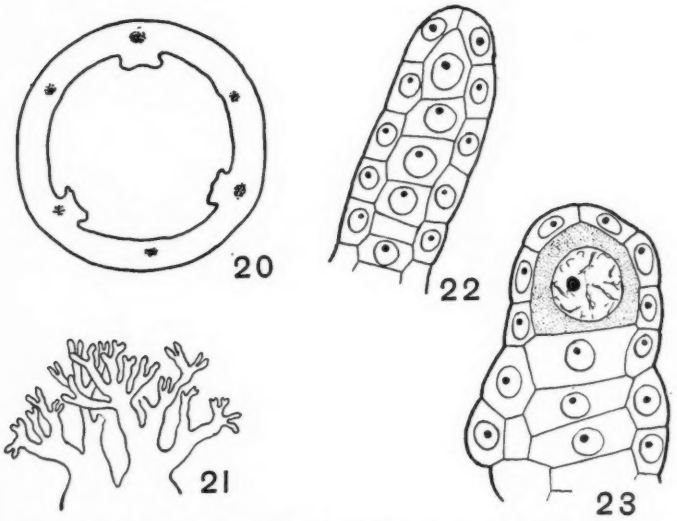
Figs. 11-19.—11. *Paphiopedilum Druryi*. Uninucleate microspore; 12-19. *Saccalobium filiforme*. Stages in the development of the pollen grain. Explanation in text. All figures, ×1129.4.

2. MEGASPOROGENESIS AND FEMALE GAMETOPHYTE

As no fundamental deviations are seen during the development of the ovule and embryo sac among the different genera and species studied at present, the phenomena will be described in a comparative manner.

Ovule.—At anthesis, the ovary shows three placental ridges running longitudinally (Fig. 20). Following pollination, the placental ridges resume an accelerated activity. The cells of the placenta begin rapid divisions to give rise to a dichotomously branching system of outgrowths (Fig. 21). Each ultimate branch possesses of a filamentous row of six or seven nucellar cells, covered by the epidermis (Fig. 22); the terminal nucellar cell of this filament differentiates itself as the archesporial cell (Fig. 23); the remaining two to four cells of the filament below the archesporial cell do not undergo any divisions but persist for a long time in many species, even after fertilization. The cells below these divide to form the integuments.

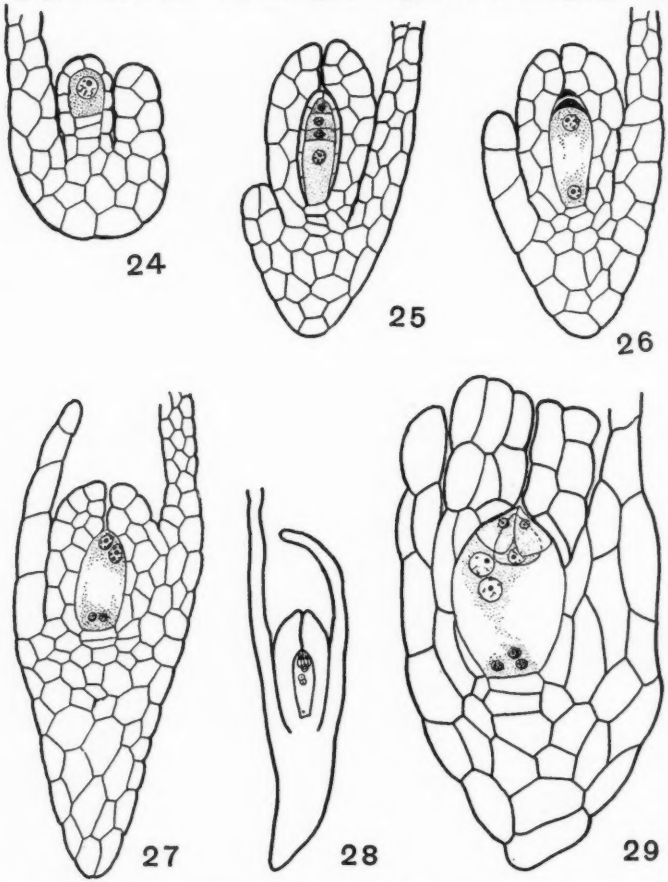
The inner integument, which is two to three cell layers thick, becomes completely organized by the time of the formation of the megaspores (Figs. 24, 25); the outer integument which consists of a single layer of cells (occasionally two towards the chalazal end) makes its appearance slightly later and outgrows the inner integument, leaving a cavity in between (Figs. 26-28).



Figs. 20-23. *Eulophia nuda.*—20. Transection of an ovary at anthesis showing the three placental ridges, ×86.4. 21. Branching system of a plancental ridge after pollination, ×158.4. 22. An ultimate branch of the placenta showing a filamentous row of nucellar cells enveloped by epidermis, ×288. 23. Differentiation of the archesporial cell, ×288.

In some species of *Dendrobium* (Fig. 29), however, the outer integument does not grow beyond the inner before fertilization.

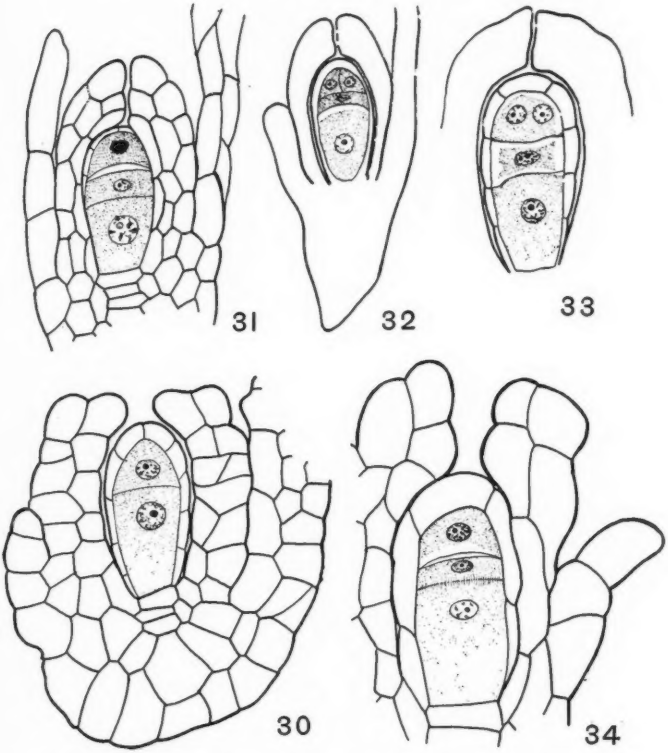
Formation of megaspores.—The archesporial cell directly functions as the megaspore mother cell. This cell slightly elongates before undergoing meiosis.



Figs. 24-29. *Bulbophyllum mysorense.*—24. Young megaspore mother cell and the origin of the inner integument, ×800. 25. Linear tetrad of megaspores, the complete organization of the inner integument and the origin of the outer integument, ×800. 26. Two-nucleate embryo sac, ×800. 27. Four-nucleate embryo sac; note the outer integument growing beyond the inner, ×800. 28. Mature embryo sac; note the empty space between the inner and outer integuments in the region of the micropyle, ×200. 29. *Dendrobium microbulbon.* Ovule at the time of fertilization; note the outer integument not overgrowing the inner, ×800.

The first division results in the dyad cells, which are of unequal sizes, the micropylar one always being the smaller (Fig. 30).

The behavior of the micropylar dyad cell is most variable. It may not undergo any division but begin prompt degeneration as such, so that after the completion of the second division in the lower dyad cell, the stage usually spoken of as "a row of three cells" results (Fig. 31); this seems to be a very general situation. However, when it divides, it does so usually by a transverse plane so that a linear tetrad is organized (Fig. 25). Occurrence of T-shaped tatrads also is not rare (Fig. 32). Instances are also not infrequent where

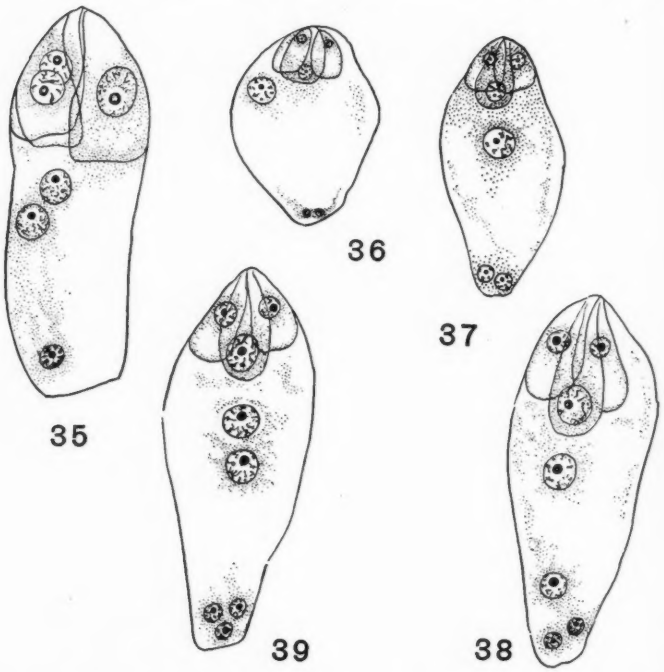


Figs. 30-34.—30. *Spathoglottis plicata.* Dyad stage. 31. *Bulbophyllum mysorense.* "Row of three cells," the micropylar cell representing the degenerating dyad cell and the lower two, the megaspores. 32. *Peristylus spiralis.* T-shaped tetrad of megaspores. 33. *Rhynchostylis retusa.* T-shaped tetrad of megaspores; note the absence of wall between the megaspore nuclei in the micropylar cell. 34. *Luisia tenuifolia.* "Row of three cells." All figures, ×869-1.

the division is not accompanied by a wall formation (Fig. 33). These different patterns of behavior are often seen in the same species.

In contrast to the micropylar dyad cell, the behavior of the chalazal is very consistent. It completes the second division by a transverse wall and here again the micropylar megaspore is always smaller (Fig. 34). The chalazal megaspore of the tetrad continues further development as mentioned below.

Embryo sac.—The nucleus of the megaspore divides to form the primary micropylar nucleus and the primary chalazal nucleus. The former by two more divisions gives rise to the egg apparatus and the micropylar polar nucleus. The primary chalazal nucleus behaves in a variable manner. In the majority of the species studied at present, it normally undergoes two divisions to constitute the three antipodal nuclei and the antipodal polar nucleus. In *Bulbophyllum* (Figs. 35, 36), *Geodorum* (Fig. 37) and rarely



Figs. 35-39.—35. *Bulbophyllum neilgherrense*. Six-nucleate mature embryo sac. 36. *B. mysorense*. The same. 37. *Geodorum densiflorum*. Mature embryo sac with six nuclei. 38. *Eulophia nuda*. Seven-nucleate embryo sac. 39. Eight-nucleate embryo sac. All figures, ×829.8.

in *Eulophia*, the primary chalazal nucleus divides only once so that the mature embryo sac is six-nucleate; fairly commonly in *Eulophia* and occasionally in *Geodorum*, only one or both of the chalazal nuclei of the four-nucleate embryo sac divide further, whereby the mature gametophyte has respectively seven (Fig. 38) or eight (Fig. 39) nuclei.

The structure of the secondary embryo sac nucleus may also be often variable. In those instances where the mature gametophyte is eight-nucleate, it is constituted of the micropylar and antipodal polar nuclei (Fig. 39). But when there is a reduction in the number of chalazal nuclei, the respective nucleus may or may not be differentiated (Figs. 35, 36). Needless to mention that such variability is seen in the different ovules of the same ovary. However, in all instances where both polar nuclei are constituted, they fuse before fertilization.

IV. DISCUSSION

1. ANTHER

Much information is not available regarding the development of the anther wall in orchids. In the genera studied at present, the primary parietal layer gives rise to endothecium, one or two middle layers and tapetum. Since the epidermis disorganizes at maturity, the endothecium is exposed and becomes the outermost layer of the anther. The fibrous thickenings are well developed in the epiphytic species but is less conspicuous in the terrestrial. In the tribe Sarcanthinae, *Dendrobium* and *Spathoglottis*, four or five layers of cells surrounding the pollinium towards its stalk end, also show fibrous thickenings at maturity.

The tapetum is of the secretory type and as a rule single-layered, although it may become two-layered at a few places here and there. The cells of the tapetum remain uninucleate in all the Monandrae; a binucleate condition has been seen only in *Paphiopedilum*, belonging to the Diandrae.

Guignard (1882) reported a successive division of microspore mother cells in the diandrous genus, *Cypripedium*. But Suessenguth (1919) and Yahama (1926) note the simultaneous type in *Cypripedium* as well as in the allied *Paphiopedilum*. Guignard's observations thus look to be very improbable. Since all the genera and species of orchids, which have been studied so far, also show the simultaneous type, this may be taken as the characteristic feature of the whole family.

The microspores may be arranged in an isobilateral or less commonly, a tetrahedral manner. In *Habenaria* (Swamy, 1946), some species of *Dendrobium*, *Bulbophyllum*, and in several members of the tribe Sarcanthinae, occasionally linear and T-shaped tetrads are also seen. In some members of the tribe Cypripedilinae, *Cephalanthera* (Barber, 1942) and *Vanilla* (Swamy, 1947) which are characterized by the possession of free pollen, the microspores separate from one another and become free. *Pogonia* (Rolfe, 1909) and *Spiranthes* (Swamy, unpublished) show the first step in the adherence of the pollen grains. Here, the pollen is still powdery, but the microspores of a tetrad cling together and are said to form "compound grains." In the entire

tribe Ophrydinae and in some members of the tribe Neottiinae, the "compound grains" themselves are held together in small units known as massulae. It has been shown in the present study that this condition of the mature pollen is foreshadowed when the archesporial cells divide to form the microspore mother cells. In the more advanced tribes, even this distinction is lost and all the "compound grains" remain together in a single mass called the pollinium.

In most angiosperms, the microspore nucleus comes to lie at one end of the cell, while the other shows a large vacuole. The orchids seem to be an exception in that no vacuole is seen here. In all cases the generative cell is cut off towards the outer wall of the microspore. This is easily observed in those genera in which the microspores do not separate from one another. The cell-plate laid down between the two cells — vegetative and generative — is of a transitory nature. Later, the generative cell becomes imbedded in the vegetative cell and at this stage the former is seen to be surrounded by a clear space.

The question of the movement of the generative cell into the plasma of the vegetative cell has already been reviewed by Wulff and Maheshwari (1938) and Maheshwari (1948). Some authors have suggested that the vegetative cytoplasm "engulfs" the generative cell by its aggressive activity. Others have expressed the opposite view that the generative cell alone is responsible for its inward movement into the vegetative cell. Friemann (1910) and Wefelscheid (1911) take an intermediate position and consider that the activities of both cells are involved. So far as the orchids are concerned, my own observation may be summarized as follows: The generative cell, which is lens-shaped at first, soon becomes crescent-shaped in outline. At the same time the plasma of the vegetative cell increases in volume and presses against the generative cell. Slightly later, the vegetative plasma is seen pushing between the wall of the pollen grain and the generative cell (see also Swamy, 1943b, Fig. 12). These observations seem to indicate that the separation of the generative cell from the wall of the pollen grain depends more on the activity of the vegetative plasma than that of the generative cell itself. Eventually the latter may be found in almost any part of the vegetative plasma.

Pollen is shed at the two-celled stage and germination commences after pollination. Pollen tube emerges from any portion of the germinal furrow, situated on the distal face of the grain. In the majority of instances, the vegetative nucleus enters the pollen tube first and then the generative cell. While the pollen tube is still in the gynostegium, the generative cell divides to form the two male nuclei which seem to be devoid of any plasma sheath.

It has been stated above that the vegetative nucleus is larger and stains less deeply than the generative. Its staining capacity becomes still less in the pollen tube. At the time when the pollen tube reaches the micropyle, the vegetative nucleus will have undergone degeneration after slight hypertrophy. *Cymbidium bicolor* affords a remarkable instance where the vegetative nucleus elongates to nearly 18 times its original length and its nucleolus fragments (Swamy, 1941).

2. OVULE

The placental ridges in the ovary usually become active only after pollination,* and give rise to short filamentous protuberances which represent the young nuclei. The terminal cell of the axial row in each nucellus becomes the archesporial cell but the next two to four cells lying below this frequently persist for a long time and may be recognizable even after fertilization. Pastrana and Santos (1930) attribute a haustorial function to such cells.

Integuments.—The inner integument arises from the base of the filamentous nucellus and completes its organization by the time of formation of the megaspores. The outer integument originates slightly later and outgrows the inner by the time the embryo sac reaches maturity. In the greatest majority of orchids, the inner integument consists of two or three layers of cells but the outer is composed of a single layer or at irregular intervals, of two layers of cells. *Vanilla planifolia* (Swamy, 1947) is an exception, for here, the inner integument is three to four layered and the outer, four to five layered.

Archesporium.—The archesporial cell functions directly as the megaspore mother cell. In *Gastrodia* (Kusano, 1915) and *Cypripedium* (Pace, 1907) two cells are found sometimes. In the former plant, occasionally both develop into embryo sacs. In *Oncidium* (Afzelius, 1916), a cell of the nucellar epidermis sometimes takes the appearance of a megaspore mother cell.

Megaspores.—The megaspore mother cell divides to form the dyad cells. The micropylar cell and its nucleus are almost always smaller than the lower. The former cell usually undergoes degeneration but quite often divides by a transverse or longitudinal wall, or no wall may be formed between the nuclei. The lower dyad cell gives rise to two megaspores. Even here, the upper cell is always smaller than the lower and this difference in size is often foreshadowed by the position of the spindle in the cell. *Satyrium napalense* (Swamy, 1944) is an exception, for here the dyad, as well as the tetrad cells are of approximately the same size soon after formation.

In all instances where four megaspores are formed, the first reduction division is always accompanied by wall formation; and the lowest megaspore of the tetrad functions. Only in *Calopogon pulchellus* (Pace, 1909), it is said that occasionally wall formation is wanting; but even here, the micropylar megaspore nuclei promptly degenerate.

Embryo sac—Monosporic type.—The chalazal megaspore nucleus divides thrice to give rise to the mature embryo sac. This development is characterized by a tendency towards a reduction and ultimate suppression of the divisions at the chalazal end of the embryo sac. Such of those orchids that exhibit this tendency are listed in Table I.

A six-nucleate condition, derived by a single division of the primary

* Even an application of a pollen extract or an appropriate hormone often suffices for initiating further activity in the ovary. But such activity does not proceed beyond the differentiation of the archesporium (unpublished data of the author).

TABLE I showing orchids that exhibit a reduction in the number of nuclei in embryo sac.*

Plant	Number of nuclei in the embryo sac	Author
Diandrae:		
Paphiopedilum insigne	6	Afzelius, 1916
Cypripedium guttatum	5 or 6	Prosina, 1930
C. parviflorum	5 or 6	Carlson, 1945
C. spectabile	6, 7 or 8	Swamy, 1945
Monandrae:		
Ophrydinae	6	
Serapias lingua	5, 7 or 8	Pardi, 1937
Orchis morio	6, 7 or 8	Afzelius, 1916
Chaemoeorchis alpina	6	Afzelius, 1916
Plantanthera obtusa	6	Afzelius, 1916
P. chlorantha	6 or 8	Afzelius, 1916
Satyrium nepalense		Swamy, 1944
Neottiinae		
Vanilla planifolia	6	Swamy, 1947
Epictactis pubescens	6 or 8	Brown and Sharp, 1911
Neottia nidus-avis	6	Modilewski, 1918
Spiranthes pseudocordigera	6 or 7	Baranow, 1915
S. australis	6 or 7	Baranow, 1915
S. cernua	5, 6 or 8	Pace, 1914
S. gracilis	5, 6 or 8	Pace, 1914
Listera ovata	6	Tuschnajakowa, 1929
Liparidinae		
Coralorrhiza maculata	6	Sharp, 1912
Broughtonia sanguinea	6	Sharp, 1912
Acroanthes monophyllos	6 or 8	Stenar, 1937
Phajunae		
Phajus grandifolius	4, 6 or 8	Sharp, 1912
Bletia shepherdi	4, 6 or 8	Sharp, 1912
Cyrtopodinae		
Geodorum densiflorum	6, 7 or 8	Present study
Eulophia epidendraea	6, 7 or 8	Swamy, 1943a
E. nuda	6, 7 or 8	Present study
Cymbidiinae		
Cymbidium bicolor	6 or 8	Swamy, 1942
Bulbophyllinae		
Bulbophyllum mysorense	6	Present study
B. neilgherrense	6	Present study
Oncidiinae		
Oncidium praetextum	5 or 6	Afzelius, 1916

* In this table no attempt is made to separate the genera and species according to their type of embryo sac development in order to emphasize that the reduction in the number of chalazal nuclei occurs throughout the family, irrespective of the type of development, i.e., monosporic, bisporic or tetrasporic.

chalazal nucleus is fairly common (see Table I). One of the two chalazal nuclei functions as a polar nucleus in *Bulbophyllum neilgherrense* (present study), *Orchis morio* (Afzelius, 1916), *Eulophia epidendraea* (sometimes, Swamy, 1943b); or, both may degenerate *in situ* as in *Listera ovata* (Tuschnajakowa, 1929), *Vanilla planifolia* (Swamy, 1947), and *Bulbophyllum mysorense* (present study). However, it must be borne in mind that both the conditions are often seen in the same species. *Phajus grandifolius* (Sharp, 1912) is an exception in which both the chalazal nuclei fuse with the micropylar polar nucleus. In some other orchids, one of the chalazal pair of nuclei of the four-nucleate stage undergoes a further division so that the mature embryo sac becomes seven-nucleate.

In *Spiranthes cernua, S. gracilis* (Pace, 1914), *Orchis morio, Oncidium praetextum* (Afzelius, 1916), *Cypripedium guttatum* (Prosina, 1930) and *C. parviflorum* (Carlson, 1945), sometimes five-nucleate embryo sacs are formed owing to the fact that the primary chalazal nucleus remains undivided. In the last four species, the five-nucleate condition may also be due to a fusion in the chalazal pair of nuclei. Such a behavior is also occasionally seen in *Gastrodia* (Kusano, 1915).

In *Paphiopedilum insigne* (Afzelius, 1916) and *Epipactis pubescens* (Brown and Sharp, 1911), the six-nucleate condition originates differently. Here, the two daughter nuclei formed by the division of the primary chalazal nucleus begins to divide again, but during the metaphase or anaphase, the two spindles fuse so that two diploid nuclei are formed. The mature embryo sac thus has four haploid nuclei at the micropylar end and two diploid nuclei at the antipodal end. None of the chalazal nuclei functions as a lower polar nucleus and they degenerate *in situ*.

The only examples of four-nucleate embryo sacs among orchids are those exhibited by *Bletia shepherdii* and *Phajus grandifolius* (Sharp, 1912). In the first plant, the megaspore nuclei may either be separated by walls or not. In the former case, the chalazal megaspore is said to develop into a four-nucleate embryo sac. However, the figures do not indicate that this is the mature condition, but gives the impression that one more division of the four nuclei is highly probable.

In *Phajus grandifolius,* the four-nucleate condition is said to be due to the fusion of the chalazal nuclei with the upper polar nucleus. After the four-nucleate stage, the micropylar nuclei alone undergo one more division so that the mature gametophyte becomes six-nucleate. The upper polar nucleus migrates down to the chalaza where it fuses with the chalazal nuclei, so that the mature embryo sac has an egg apparatus and a triploid secondary embryo sac nucleus. Thus this instance also cannot be considered as a tetra-nucleate embryo sac in the strict sense.

It may also be mentioned here that it is a general feature in the embryo sacs of orchids to find that at the four-nucleate stage and onwards, the chalazal nuclei appear very much diminished in size.

Embryo sac—Bisporic type: Orchids that show a bisporic embryo sac are listed in Table II. A perusal of this would show that such species are not confined to any particular group but are scattered among different tribes of the family. It is, however, interesting to note that all the genera and species belonging to the Diandrae, which have so far been embryologically studied, show the Allium-type of development without an exception.

TABLE II showing orchids having bisporic embryo sacs.

Plant	Author	Remarks
Diandrae		
Cypripedium spectabile	Pace, 1907; Swamy, 1945	
C. pubescens	Pace, 1907	
C. parviflorum	Pace, 1907; Carlson, 1945	
C. candidum	Pace, 1907	
C. guttatum	Prosina, 1930	
Paphiopedilum insigne	Afzelius, 1916	
P. Leeanum	Francini, 1931	
P. spicerianum	Francini, 1931	
P. barbatum	Francini, 1931	
P. villosum	Francini, 1931	
P. venustum	Francini, 1931	
Monandrae		
Orchis sambucina	Afzelius, 1916	Only sometimes
Epipactis latifolia	Vermoessen, 1911	Only sometimes
E. pubescens	Brown and Sharp, 1911	Only sometimes
Neottia nidus-avis	Modilewski, 1918	
Spiranthes cernua	Pace, 1914	Only sometimes
S. gracilis	Pace, 1914	Only sometimes
Cymbidium bicolor	Swamy, 1942	
Oncidium praetextum	Afzelius, 1916	Only sometimes

It would be fitting in this connection to say a few words about the embryo sac of *Cypripedium*, the exact nature of which has been the subject of frequent discussion.* Briefly, the "Cypripedium type" of embryo sac was founded upon the account of Pace (1907) who reported a four-nucleate embryo sac in several species of the genus. Rutgers (1923) questioned this and gave a different interpretation of her illustrations. The subsequent studies of Prosina (1930) and Francini (1931) established that the development of the embryo sac follows the Allium-type, with the only difference that the number of nuclei at the chalazal end is less than four. This has been confirmed in *C. parviflorum* (Carlson, 1945) and *C. spectabile* (Swamy, 1945).

Neottia nidus-avis (Modilewski, 1918) and *Cymbidium bicolor* (Swamy, 1942) are the only monandrous orchids which show the Allium-type of development always. As can be seen from the remarks column in Table II, the remainder of the orchids have monosporic embryo sacs normally but show the bisporic method in rare instances.

* For details see, Rutgers (1923), Schnarf (1929, 1936), Maheshwari (1937, 1941), Swamy (1945).

Embryo sac—Tetrasporic type—Those orchids that are said to exhibit a tetrasporic embryo sac are brought together in Table III. The Adoxa-type occurs only as an abnormality, the monosporic method being the rule. Such variations may often occur in the ovules of one and the same ovary. Brown and Sharp (1911) and Sharp (1912) lay much stress on the position of the meiotic spindles as the determining factor for one or the other type of development and attribute the variability in regard to the former to be due to some environmental factor such as nutrition.

TABLE III showing orchids having tetrasporic embryo sacs.

Plant	Author	Remarks
Epipactis pubescens	Brown and Sharp, 1911	Occasionally
Spiranthes cernua	Pace, 1914	Sometimes
S. gracilis	Pace, 1914	Sometimes
Epidendrum variegatum	Sharp, 1912	Very rarely
Bletia shepherdii	Sharp, 1912	Very rarely

V. SUMMARY

The gametophytes of 15 genera and 27 species of orchids are studied.

The structure of the anther and the development of the male gametophyte are quite uniform throughout the family. The anther wall consists of four or five layers of cells including the epidermis. The tapetum is of the secretory type and its cells are uninucleate in all monandrous orchids. A binucleate type is observed only in *Paphiopedilum* (Diandrae).

Pollen is found in four morphological forms: free pollen grains, compound grains, massulae and pollinia. The first condition is prevalent in the diandrous orchids and also occurs in a small number of species of the monandrous orchids; the second condition is seen in several genera of the tribe Neottiinae; the third, in a number of genera of the tribe Ophrydinae; and the fourth, in the higher and epiphytic members of the Monandrae.

The microspore mother cells undergo two simultaneous divisions to form tetrads of microspores. The division of the microspore results in the formation of vegetative and generative cells, the latter always being cut off towards the exterior side. Later, the generative cell becomes imbedded in the cytoplasm of the vegetative cell and its position is quite variable. Division of the generative cell to form the two male gametes is accomplished in the pollen tube.

The ovules differentiate only after pollination. The outer integument. which is made up of a single layer of cells outgrows the inner which is two to three layered. An empty space is formed at the micropylar region of the ovule between the two integuments.

There is a single hypodermal archesporial cell which functions directly as the megaspore mother cell. In the great majority of species, the embryo sac is of the monosporic eight-nucleate type. It is interesting to note that all the diandrous orchids are characterized by the Allium-type of development.

whereas in the monandrous orchids this occurs only in *Neottia* and *Cymbidium*.

There is a strong tendency towards a reduction of the number of nuclei at the chalazal end. Thus the mature embryo sac may often contain 8, 7, 6 or 5 nuclei, depending upon the extent of the reduction; or frequently a lower polar nucleus is absent. In some exceptional cases there is a reduction in the number of nuclei owing to a fusion of spindles.

ACKNOWLEDGEMENT

I am very grateful to Prof. P. Maheshwari of the Dacca University for his suggestions during the preparation of this paper and his constant encouragement.

REFERENCES

AFZELIUS, K. 1916—Zur Embryosackentwicklung der Orchideen. Svensk bot. Tidskr. 10: 183-227.

BARANOW, P. 1915—Recherches sur le développement du sac embryonnaire chez les *Spiranthes australis* Lindl. et *Serapias pseudocordigera* Morie. Bull. soc. imp. Nat. Moscou. N. S. 29: 74-92.

BARBER, H. N. 1942—The pollen grain division in the Orchidaceae. Jour. Gen. 43: 97-103.

BROWN, W. H. AND L. W. SHARP 1911—The embryo sac of *Epipactis*. Bot. Gaz. 52: 439-452.

CARLSON, M. C. 1945—Megasporogenesis and development of embryo sac of *Cypripedium parviflorum*. Ibid. 107: 107-114.

FRANCINI, E. 1931—Ricerche embryologische e cariologiche sul genere Cypripedium. Nuovo giorn. bot. Ital. 38: 154-212.

FRIEMANN, W. 1910—Über die Entwicklung der generativen Zelle im Pollkorn der monocotylen Pflanzen. Diss. Bonn.

GUIGNARD, L. 1882—Recherches sur le développement de l'anthère et du pollen chez les Orchidées. Ann. sc. nat. VI. Bot. 14: 26-45.

KUSANO, S. 1915—Experimental studies on the embryonal development in an Angiosperm. J. Coll. Agric. Tokyo 6: 7-120.

MAHESHWARI, P. 1937—A critical review of the types of embryo sacs in Angiosperms. New Phytol. 36: 359-417.

———1941—Recent work on the types of embryo sacs in Angiosperms—A critical Review. Jour. Indian Bot. Soc. 20: 229-261.

———1948—The male gametophyte of Angiosperms. (In press).

MODILEWSKI, J. 1918—Cytological and embryological studies on *Neottia nidus-avis* (L.) Rich. Verh. Kiewer Ges. Naturf. 26: 1-55.

PACE, L. 1907—Fertilization in *Cypripedium*. Bot. Gaz. 44: 353-374.

———1909—The gametophytes of *Calopogon*. Ibid. 48: 126-137.

———1914—Two species of *Gyrostachys*. Baylor Univ. Bull. 17: 1-16.

PARDI, L. 1937—Il gametophyto femmineo di "*Serapias lingua* L." Nuovo giorn. bot. Ital. 44: 324-329.

PASTRANA, M. D. AND J. K. SANTOS 1931—A contribution on the life history of *Dendrobium anosum* Lindley. Nat. & Appl. Sci. Bull. (Philippines). 1: 133-144.

PFITZER, E. 1889—Orchidaceae in Engler's Die natürlichen Pflanzenfamilien.

PROSINA, M. N. 1930—Über die von Cypripedium-Typus abweichende Embryosackentwicklung von *Cypripedium guttatum* Sw. Planta 12: 532-544.

ROLFE, R. A. 1909—The evolution of the Orchidaceae. Orchid Review, 1909-1912:

129-132; 193-195; 289-292; 353-356. 33-36; 97-99; 129-132; 162-166; 289-294; 321-325. 68-69; 289-292. 204-207; 225-228; 260-264.

RUTGERS, F. L. 1923—Embryo sac and embryo of *Moringa oleifera*. The female gametophyte of Angiosperms. Ann. Jard. bot. Buitenzorg 33: 1-66.

SCHNARF, K. 1929—Embryologie der Angiospermen. Berlin.

———1931—Vergleichende Embryologie der Angiospermen. Ibid.

———1936—Contemporary understanding of the embryo sac development among angiosperms. Bot. Rev. 2: 565-585.

SESSHAGIRIAH, K. N. 1941—Morphological studies in Orchidaceae. I. *Zeuxine sulcata* Lindley. Jour. Indian Bot. Soc. 20: 357-365.

SHARP, L. W. 1912—The orchid embryo sac. Bot. Gaz. 54: 373-385.

STENAR, H. 1937—Om *Acroanthes monophyllos* (L.) Greene, dess Geografiska utbredning och embryologi. Festkrift till Fil. der Erik Modin, Heimbygdas Tideskr. Fornvardaren, 1937-38, 177-221.

SUESSENGUTH, K. 1919—Beiträge zur Frage des systematischen Anschlusses der Monocotylen. Diss. Munchen.

SWAMY, B. G. L. 1941—The development of the male gamete in *Cymbidium bicolor* Lindl. Proc. Indian Acad. Sci. B. 14: 454-460.

———1942—Female gametophyte and embryogeny in *Cymbidium bicolor* Lindl. Ibid. 15: 194-201.

———1943a—Embryology of Orchidaceae. Curr. Sci. 12: 13-17.

———1943b—Gametogenesis and embryogeny of *Eulophia epidendraea* Fischer. Proc. Nat. Inst. Sci. India 9: 59-65.

———1944—Embryo sac and embryo of *Satyrium nepalense* Don. Jour. Indian Bot. Soc. 23: 66-70.

———1945—Embryo sac and fertilization in *Cypripedium spectabile*. Bot. Gaz. 107: 291-295.

———1946—Embryology of *Habenaria*. Proc. Nat. Inst. Sci. India 12: 413-426.

———1947—On the life history of *Vanilla planifolia*. Bot. Gaz. 108: 449-456.

TUSCHNAJAKOWA, M. 1929—Embryologische und zytologische Beobachtungen an *Listera ovata* (Orchidaceae). Planta 7: 29-44.

WEFELSCHEID, G. 1911—Über die Entwicklung der generativen Zelle im Pollenkorn der dikotylen Angiospermen. Diss. Bonn.

WULFF, H. D. AND P. MAHESHWARI 1938—The male gametophyte of Angiosperms (A critical review). Jour. Indian Bot. Soc. 17: 117-140.

YAMAHA, G. 1926—Über die Zytokinese bei der Pollentetradenbildung, zugleich weitere Belege zur Kenntnis der Zytokinese im Pflanzenreiche. Jap. Jour. Bot. 3: 139-162.

Embryological Studies in the Orchidaceae. II. Embryogeny

B. G. L. Swamy

Biological Laboratories, Harvard University, Cambridge 38, Mass.

CONTENTS

Observations 202
Pollination 202
Embryogeny 204
Seed 208
Carpellary wall 208
Discussion 209
Fertilization 209
Endosperm 210
Embryo 210
Suspensor 214
Classification of the orchid embryos 217
Polyembryony and apomixis 219
Fruit 221
Seed 221
Embryological tendencies in the Orchidaceae and Embryological formula 222
Some systematic considerations 224
Summary 228
Acknowledgements 229
References 230

The present study is a continuation of the one recently published by the author (1948 *b*), where he described the development of the gametophytes. In the following pages the development of the embryo in some orchids will be described. The source of material and the technique have already been outlined in the previous paper. Through the kindness of Drs. A. G. Kevorkian and F. G. Walsingham of the Atkins Garden and Research Laboratory, Cuba, I recently received the material *Epidendrum lacerum*. I have included my observations on this plant also in the present paper. In addition to serial microtome sections, observations were also checked up with whole mounts of the developing seeds. This method is particularly facilitated in the great majority of orchids by the transparent nature of their seed coat.

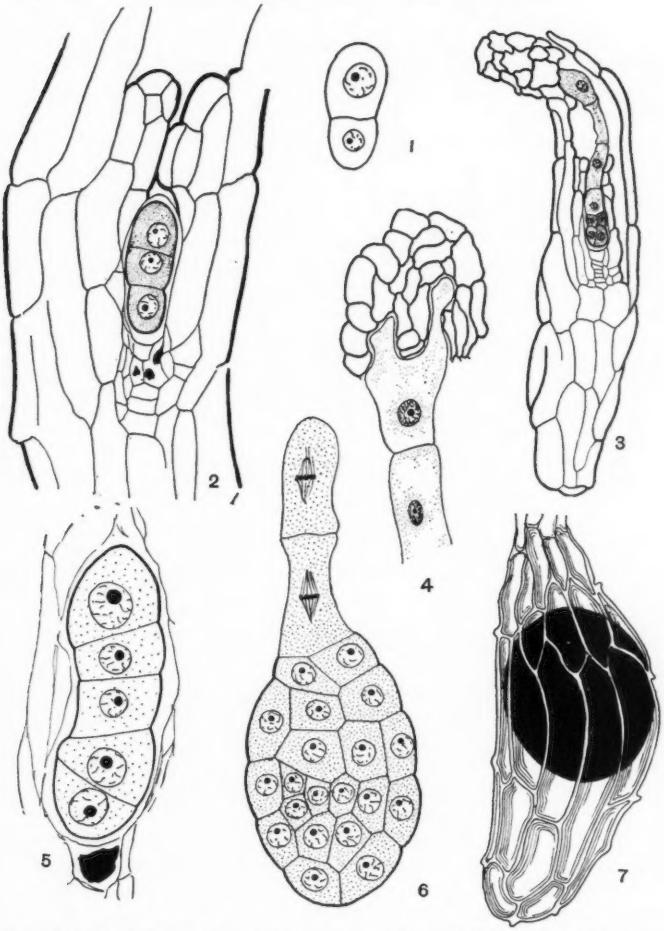
I. Observations

1. Pollination

It has long been known that in orchids the interval between pollination and fertilization is generally long. Researches of Guignard (1886) have already brought out this feature and Schnarf (1929) has tabulated the available data. The following list sums up my own observations:

Species	Duration between pollination and fertilization
Habenaria species	8 to 10 days
Satyrium nepalense	8 to 10 days
Vanilla planifolia	1 month
Spathoglottis plicata	15 days
Geodorum densiflorum	2 months
Eulophia epidendraea	1 month, 15 days
Dendrobium species	2 to 2½ months
Bulbophyllum mysorense	2 months
Cymbidium bicolor	1½ months
Members of the tribe Sarcanthinae	varying from 2 to 3 months

When this data is supplemented with Schnarf's tabulation, it becomes evident that the period is shorter in those orchids that are generally considered to be primitive and relatively longer in the more advanced.



Figs. 1-7. *Peristylus spiralis*.—1. 2-celled proembryo, ×212.4. 2. 3-celled proembryo inside the embryo sac, ×212.4. 3. Young embryo with suspensor haustorium in relation to the ovule and placenta, ×76.5. 4. Free cell of the suspensor sending out processes into the placenta, ×212.4. 5. A young proembryo, whose suspensor cells have failed to elongate out to the micropyle, ×339.8. 6. A fairly advanced embryo, whose suspensor has just commenced to be differentiated, ×339.8. 7. Mature embryo inside the seed, ×42.5.

2. EMBRYOGENY

In both the species of *Peristylus* studied at present, the zygote divides by a transverse wall (Fig. 1); the basal cell divides again in the same plane to give rise to a row of three cells (Fig. 2). Of these, for the sake of description, the last cell towards the micropyle may be designated as the "suspensor initial cell"; that towards the chalaza as the "terminal cell"; and the cell in between, as the "middle cell." This terminology will be maintained in the following account.

The suspensor initial cell divides by walls parallel to the previous ones into a linear row of five to seven cells which elongate to form the suspensor haustorium. This structure extends out of the micropyle and the free cell of the suspensor embeds itself in the placenta (Figs. 3, 4), behaving as an aggressive haustorium. The sequence of divisions in the middle and terminal cells of the proembyro were not followed in detail, but some of the later stages indicated that the development is similar to the one described for *Habenaria* (Swamy, 1946c).

Instances are occasionally seen where the basal cell, even after undergoing divisions into three or four cells, still remaining within the embryo sac (Fig. 5). Further, the suspensor cells may often show a belated development (Fig. 6). The mature embryo is an ovoid mass of cells and occupies the center of the air-filled seed cavity (Fig. 7).

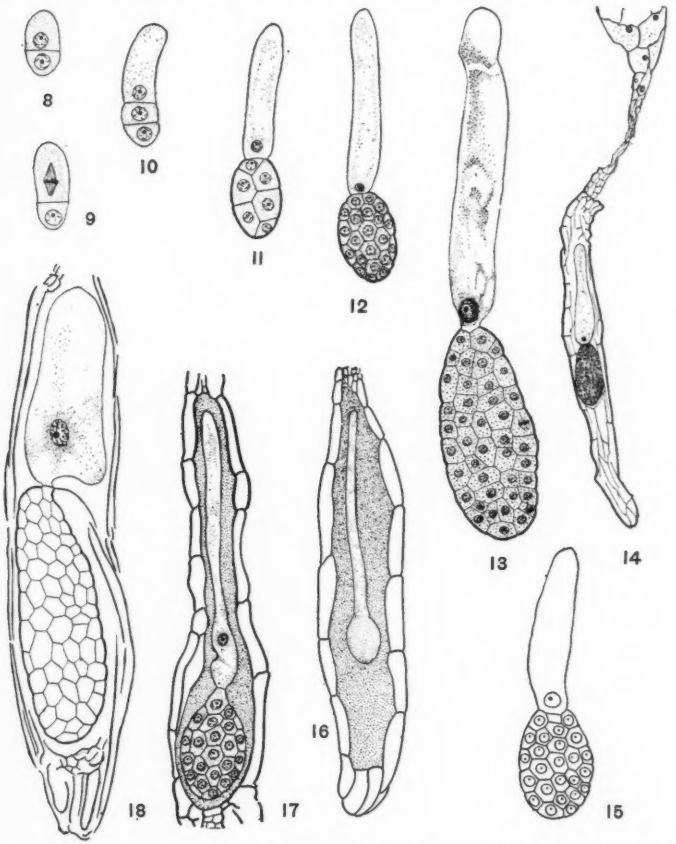
Coelogyne, Spathoglottis, Bulbophyllum, Peristeria and *Dendrobium* show a uniform type of embryogeny. After the zygote forms a proembyro of three cells (Figs. 8-10), the suspensor initial cell does not undergo any further divisions. The middle and terminal cells by subsequent divisions give rise to the embryonal mass proper. It must be noted that the terminal cell contributes a larger number of cells to the body of the embryo than the middle cell.

The undivided suspensor initial cell in *Dendrobium microbulbon* and *D graminifolium* undergoes neither enlargement nor any significant modifications. It persists in the mature embryo as a distinct vacuolate cell at the apex of the embryonal mass (Figs. 19-23).

In all the other genera mentioned above, the suspensor initial cell elongates, sometimes to enormous proportions (Figs. 13, 16, 17), in the form of a tubular structure. However, the shape varies in the different genera although in minor respects. Thus in *Coelogyne* (Fig. 15) and *Peristeria* (Fig. 16), the suspensor is tubular; in *Spathoglottis* (Figs. 13, 14) and *Bulbophyllum* (Fig. 17), it is slightly constricted at the point of attachment with the embryonal mass; further, in *Spathoglottis*, the nucleus of the suspensor cell is characteristically situated at the constricted region; in *Dendrobium barbatulum* (Fig. 18), the linear dimension is less pronounced whereas the constriction is carried to an extreme point.

The course of development of the embryo and suspensor in *Epidendrum lacerum* follows the same pattern as is described for *E. prismatocarpum* (Swamy, 1948a) and hence a repetition here is omitted.

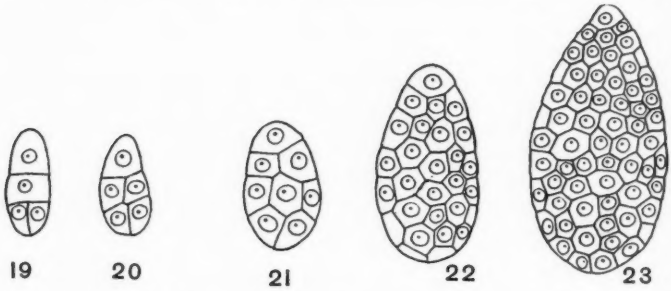
All the genera of the tribe Sarcanthinae studied at present exhibit a stereotyped pattern of embryogeny. The suspensor initial cell undergoes three successive divisions by vertical walls so that a plate of eight cells are produced (Figs. 24-28a). While the middle and terminal cells develop into the embryonal mass, the eight cells of the suspensor elongate in a tubular manner over the embryo (Figs. 29-31). The elongation is chiefly confined



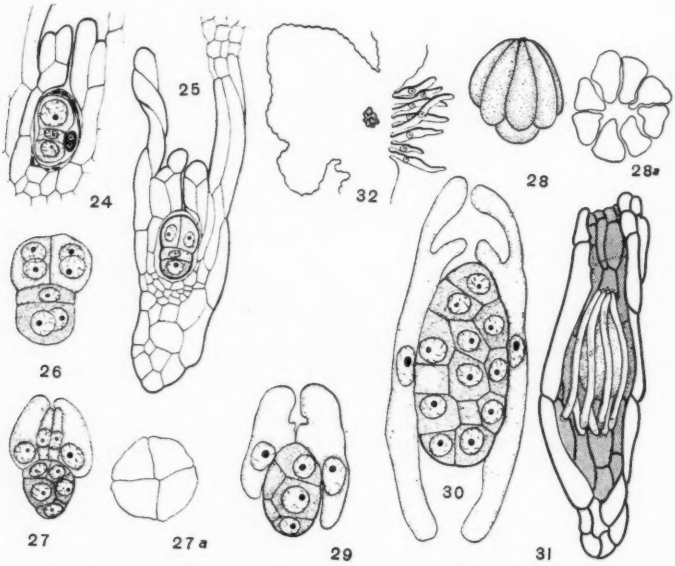
Figs. 8-14. *Spathoglottis plicata*.—8. 2-celled proembryo, ×164. 9. Basal cell of the 2-celled proembryo in division, ×164. 10. 3-celled proembryo, ×164. 11-13. Subsequent stages in the development of the suspensor and the embryonal mass, ×328. 14. L. s. of a seed showing the embryo and suspensor in relation to the seed, ×82. 15. *Coelogyne breviscapa*. Embryo showing the single-celled suspensor, ×205. 16. *Peristeria elata*. Embryo with tubular suspensor inside the seed, ×205. 17. *Bulbophyllum mysorense*. Embryo and suspensor inside the seed, ×205. 18. *Dendrobium barbatulum*. Embryo and suspensor inside the seed, ×266.5.

towards the chalaza. However, in *Diplocentrum* they may extend slightly toward the micropyle also and while doing so give out a short branch centripetally (Figs. 29, 30).

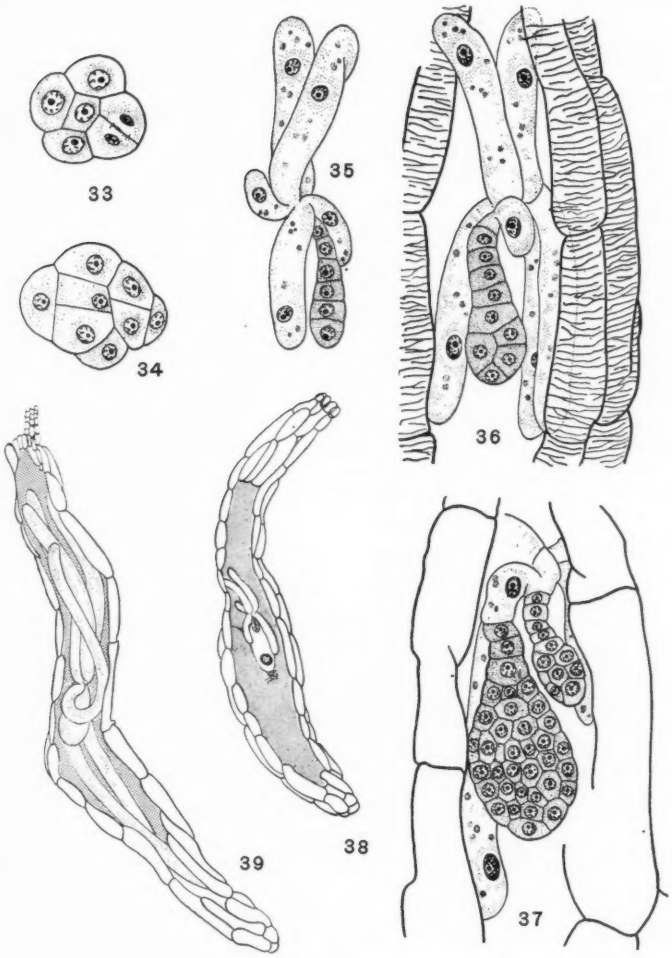
The type of embryogeny presented by *Eulophia* and *Geodorum* is very much different from the types described till now. The zygote divides by a



Figs. 19-23. *Dendrobium microbulbon*. Stages in the development of embryo.—19-21, ×290.5. 22, 23, ×213.3.



Figs. 24-32. *Diplocentrum conjestrum*.—24-30. Stages in the development of suspensor and embryonal mass, ×233.2. 31. L. s. of mature seed showing the relation of the embryo and suspensor, ×77.7. 32. T. s. of a portion of the fruit wall at the region of the development of hygroscopic hairs, ×31.1.



Figs. 33-39. *Geodorum densiflorum*.—33-36. Stages in the development of suspensor embryonal mass. 33, 34, ×261.8. 35, 36, ×174.5. 37. L. s. of a seed showing twin embryos, ×261.8. 38. L. s. of a young seed when the prosuspensor cells begin to elongate and the filamentous proembryo is being differentiated; note the suspensor cells elongating both toward the micropyle and chalaza, ×28.5. 39. The same, but later stage, ×52.4.

transverse wall; but the subsequent two to four divisions take place in both the cells and neither the sequence nor the plane of cell divisions are constant. Thus a mass of 4-10 cells, all irregularly arranged, is formed (Figs. 33, 34). The cells of this mass that are situated towards the micropyle develop into tubular structures, elongating in all directions (Figs. 35-39). Their nuclei become hypertrophied considerably and the entire structure functions as the suspensor. One of the un-elongated cells of the first formed cells of the zygote, divides to give rise to a filamentous row of 8-12 cells (Fig. 35). The terminally situated 2-4 cells of this filament produce the embryonal mass proper by subsequent divisions (Figs. 35-37).

It may be specially noted that the suspensor cells break through the degenerating tissue of the inner integument (Swamy, 1946b) during their elongation and finally spread out in any direction within the space limited by the outer integument (Figs. 38, 39) but never go out of the seed coat.

Polyembryony.—Of the orchids studied at present, *Eulophia nuda, Geodorum densiflorum* and *Bulbophyllum mysorense* exhibit occasionally two embryos in a seed. In the first two plants, the available evidence indicates that the additional embryos arise as a result of budding or proliferation of the sexually produced embryo. The additional embryos may originate at an early stage either from the filamentous region of the suspensor or from the body of the embryonal mass proper (Swamy, 1943) and hence all the embryos in a seed are monozygotic. In *Bulbophyllum,* the origin of twin embryos is not studied.

3. SEED

The structure of the seed coat in all the orchids studied at present is very uniform and characteristic. All the tissues of the ovule excepting the outermost layer of the outer integument disorganize by the time the seeds become mature. The persisting layer of cells of the outer integument forms the seed coat. Its cells lose their protoplasts and the entire layer becomes transparent and appears reticulate, the intricate patterns of reticulations varying with the genera. In *Eulophia nuda*, the wall of the seed coat shows transverse striations.

The mature embryo is only an undifferentiated mass of cells. The suspensor, whether simple or complicated, becomes degenerated and shrivelled. In the large majority of orchids, with a few exceptions in the tribes Dendrobinae and Sarcanthinae, the embryo occupies a central position in the air-filled cavity of the seed. In the exceptional cases, where the seeds themselves are comparatively small, the embryo fills the cavity.

4. CARPELLARY WALL

Hand in hand with the maturation of the seed, the layers of cells lining the cavity of the ovary exhibit some interesting features. In general, the cells of this layer become more conspicuous by rich proplasts after pollination. The central region of the interplacental ridges of the ovary wall in *Cymbidium* is characterized by a slight depression (d in Figs. 40, 41) running through-

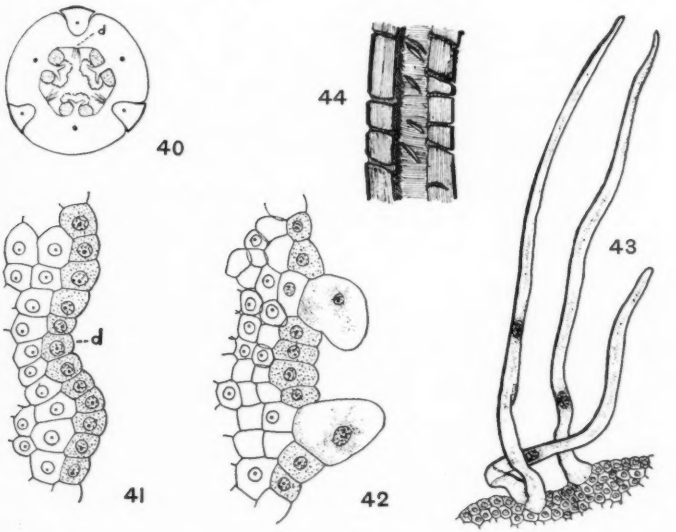
out the length of the ovary. One or two longitudinal rows of cells on either side of such depressions become further differentiated by their larger size and the cells protrude into the ovary (Fig. 42). These cells elongate (Fig. 43) to enormous length, finally attaining a size of 1.5-2.0 cms. in the mature capsule. Their nuclei and cytoplasm degenerate during later stages and the wall becomes studded with numerous slit-like pits (Fig. 44). The mature hairs possess heavily lignified wall and are remarkably hygroscopic.

An essentially similar development of hairs from the corresponding region of the ovary is seen in all members of the tribe Sarcanthinae. They originate in front of the median vascular bundles of the carpels. In these members, 10-15 cell rows develop into such hairs (Fig. 32) and at maturity attain a length of 1.0-1.5 cms.

II. DISCUSSION

1. FERTILIZATION

Mention has been made on a previous page that the period between pollination and fertilization becomes progressively prolonged in the more advanced tribes of the family. My own observations further indicate a similar situation existing between fertilization and the first division of the zygote. The zygote divides in less than two days in many members of the tribe Ophrydinae and in some members of Neottiinae; between 10 to 15 days in the tribes Phajinae, Dendrobinae, Bulbophyllinae, etc.; nearly a month in



Figs. 40-44. *Cymbidium bicolor*. Stages illustrating the origin and development of hygroscopic hairs.—40, ×9.5. 41, 42, ×95. 43, ×57. 44. ×332.7.

Cymbidiinae and Cyrtopodiinae; more than a month in the members of Sarcanthinae.

In all the members the pollen tube enters the ovule by way of the micropyle. Double fertilization is seen in all the orchids. However, instances do occur where the second sperm nucleus fails to undergo complete fusion with the secondary embryo sac nucleus before starting to degenerate. This is especially so in the more advanced members of the family.

2. ENDOSPERM

Orchidaceae is a typical example where there is a total suppression of endosperm development. Many instances are on record among the members of the family where double fertilization itself is incomplete and the second male nucleus degenerates as such. There are a large number of orchids where triple fusion is complete but the primary endosperm nucleus begins prompt degeneration. Finally, there are only half a dozen instances where the primary endosperm nucleus undergoes slightly further development. Such orchids are listed in Table I.

TABLE I showing orchids that develop endosperm.

Plant	Author	Maximum number of endosperm nuclei
Cypripedium spectabile	Pace, 1907	4
C. parviflorum	Pace, 1907	4
Paphiopedilum insigne	Afzelius, 1916	2
Chaemoeorchis alpina	Afzelius, 1916	2
Cypripedium guttatum	Prosina, 1930	4
Vanilla planifolia	Swamy, 1947	10

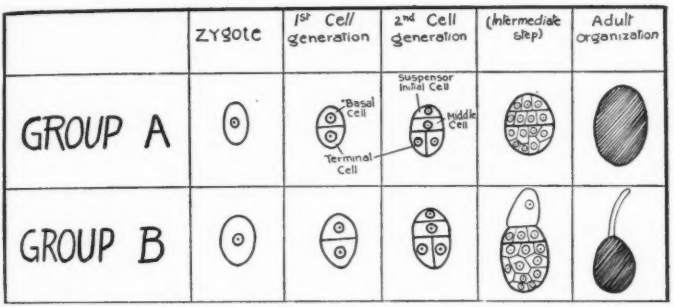
In all the endospermous orchids, the tissue is of the nuclear type, and in all the instances its development is not consistent. A proper explanation of the total lack of the development of this tissue in the orchids is still to be awaited.

3. EMBRYO

The mature embryo of the orchid is just an ovoid mass of cells without any differentiation of the tissues. It is only after the dispersal of the seeds into favorable environment that further development is initiated. This being the situation, nothing is known at present as to how exactly the undifferentiated mass of cells becomes organized into the several organs of the embryo, such as, the stem and root apicies, their relation to procambium, hypocotyl, cotyledonary leaf, etc.

Generally in orchids, only the first two or three cell generations in the zygote are consistent; the subsequent cell divisions take place with no definite sequence or pattern. In the majority of orchids, the first transverse division of the zygote results in the basal and terminal cells; during the second cell

generation, the basal cell undergoes division by a transverse wall to give rise to the suspensor initial cell and the middle cell. The division of the terminal cell is always by a vertical wall (Fig. 45). From this step onwards, two types of development may be recognized generally, — (1) wherein all the derivative cells of this stage enter into the construction of the embryo (Fig. 45, Group A), and (2) wherein the suspensor initial cell manifests itself as a distinct structure with or without further divisions and the embryonal mass proper is derived entirely from the terminal and middle cells (Fig. 45, Group B).



45

Fig. 45.—Diagrammatic representation of the developmental methods of embryos in orchids.

To the group A belong orchids like *Cypripedium reginae* (Treub, 1879), *Epipactis palustris*, *Spiranthes* (Coulter and Chamberlain, 1912), *Listera ovata* (Pfitzer, 1899), *Neottia nidus avis* (Dumee, 1910), etc. In these forms, the suspensor initial cell also undergoes divisions just in the same way as the middle and terminal cells and enters into the construction of the embryonal mass (Fig. 45, Group A). Although all the three cells contribute to the embryonal mass, the number of cells produced by each is in the following decreasing order: terminal cell, middle cell, suspensor initial cell. However, the derivatives of the latter two when put together more or less equals those of the terminal cell in number. In other words, the basal and the terminal cells may be said to have more or less equal share in the construction of the embryonal mass proper. This situation conforms to the Asterad type (Johansen, 1945).

The remainder of the orchids investigated so far possess a suspensor of one kind or other (Fig. 45, Group B). In these forms, the suspensor initial cell or its derivatives manifest themselves as the suspensor and this structure, in the majority of forms, remain distinct from the derivatives of the terminal and middle cells. The embryonal mass proper is wholly formed by the derivatives of the terminal and middle cells only. Here also, the number of cells contributed by the terminal cell is far larger than those formed by the

middle cell. In other words, the basal cell has only a minor role in the construction of the embryonal mass proper. Irrespective of the type of suspensor, these orchid embryos thus conform to the Onagrad type (Johansen, 1945).

Stanhopea (Treub, 1879), *Cymbidium* (Swamy, 1942a), *Eulophia* (Swamy, 1943, also present study) and *Geodorum* (present study) however do not seem to fit into either of the groups described above. As has been mentioned already, in these plants the divisions during the second and third cell generations in the zygote do not conform to any definite pattern or order and the result is an undifferentiated mass of 6-8 cells. Many of these take part in the formation of the complicated suspensor. One of the un-elongated cells of this proembryonal mass, preferably the one situated towards the chalazal end, develops into a filamentous row of 8-15 cells; 2-4 terminal cells of this filament give rise to the embryonal mass proper. This type of development is distinctive in the following ways: (1) A proembryo of the kind seen in the groups A and B is characteristically absent (2) The cells that are first to develop from the zygote develop into the suspensor whereas the filamentous region of the proembryo is differentiated later (3) The early development of the embryo being characterized by these factors, it is not possible to assess the share of the terminal and basal cells in the construction of the embryonal mass proper; further, it is also not possible to clarify the plane of cell division during the second cell generation of the zygote, — whether the wall is laid down in a transverse or longitudinal plane. The lack of this data precludes to refer the type of embryogeny to the Solanad type (Johansen, 1945). In view of all these points, for the sake of description, I propose to designate this type tentatively as "Cymbidium form," as this genus happens to be the first plant where such a method of embryogeny is clearly demonstrated (Swamy, 1942a).

The important points of the preceding discussion may be expressed as follows:

Orchid embryos

Zygote

- Wall transverse
  - Wall in the basal cell transverse; in the terminal cell vertical.
    - Suspensor initial cell, middle cell and terminal cell, all enter into the construction of the embryo. Suspensor absent. — Asterad type (Group A).
    - Suspensor initial cell develops into the suspensor; only middle and terminal cells enter into the construction of the embryo.— Onagrad type (Group B).
- Wall transverse
  - Further divisions irregular in both basal and terminal cells; filamentous proembryo differentiated later. Suspensor present. — Cymbidium form.

Irrespective of the method of development and presence or absence of suspensor, the mature embryo in all orchids is, as already stated, an undifferentiated mass of cells. Coulter and Chamberlain (1912) thought that this situation may be due to the lack of endosperm. However, there does not seem to be sufficient support for this view. Even in those exceptional cases of orchids that develop an endosperm the respective embryos do not develop to any higher degree than in the non-endospermous orchids. That there is no correlation between the degree of differentiation of the embryo and the presence or absence of endosperm is further indicated by the occurrence of

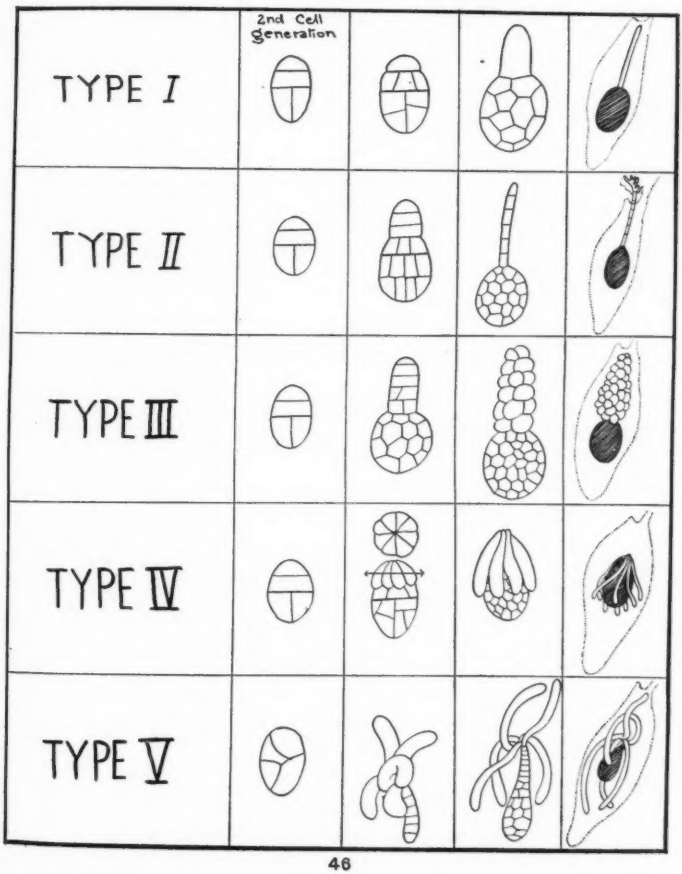


Fig. 46.—Diagrammatic representation of the types of suspensors in orchid embryos.

more highly differentiated embryos in the following non-endospermous orchids: *Platyclinis* (Rendle, 1930), *Dendrochilum* (Pfitzer, 1899), both of which are said to possess a green cotyledon; *Sobralia* (Treub, 1879), which has a differentiation into cotyledon and hypocotyl. Furthermore, the fact that the embryo in the non-endospermous Podostemaceae is normal and complete makes us all the more sceptical of Coulter and Chamberlain's view. A convincing explanation as to the undifferentiated nature of the orchid embryo is to be awaited.

Treub (1879) concluded from his studies on orchids that the suspensorless forms are less resistent in the struggle for existence than those other orchids which possess a suspensor. There is no adequate evidence in favor of this.

4. SUSPENSOR

This organ in orchids exhibits a remarkable diversity. The family includes generic elements which range from those without a suspensor to those with extraordinarily complex modifications of this organ. In any survey of the variations in the pattern of the suspensor development in this family, we must first isolate as a special group those genera which never develop a suspensor (see page 211). All the other orchids that possess a suspensor may be grouped under one of the following five fairly compact types (see also Fig. 46):

TYPE *I*. In this category, the suspensor initial cell does not undergo any division but persists without much elongation (species of *Cypripedium* and *Dendrobium*), or grows to enormous proportions (*Peristeria, Spathoglottis, Goodyera,* etc.). The ultimate form of such an elongated suspensor may become sac-like, conical, tubular, cist-like, etc., depending upon the genus and species. As a rule, in this type, the suspensor does not elongate beyond the limits of the seed cavity.

TYPE *II*. In this category, the suspensor initial cell divides into a filamentous row of 5-10 cells and the entire filament elongates out of the micropyle; the free cell of the filament implants itself in the placenta and sends out haustorial processes into the nutritive tissue. This is the only type of suspensor in the orchid family that behaves as a true extra-ovular haustorium. This type is characteristically seen in *Ophyrs, Habenaria, Satyrium,* etc.

A minor variation of this type is seen in *Corallorrhiza* and *Aplectrum* (Leavitt, 1901). In these plants, it is said that the suspensor initial cell divides only once and the cells elongate out of the micropyle to get themselves embedded in the placenta.

TYPE *III*. The suspensor initial cell in this kind undergoes several transverse divisions, after the cessation of which oblique and vertical divisions occur in the transversely divided cells. The individual cells become swollen, thereby appearing like a bunch of grapes. This type may be seen in *Epidendrum, Sobralia,* etc.

TYPE *IV*. The suspensor initial cell divides thrice by vertical walls to form a plate of eight cells. The cells grow towards the chalaza, enveloping the embryonal mass proper. *Luisia, Cottonia, Vanda, Saccolabium,* etc., are some of the genera to exhibit this type of suspensor. The individual cells of the suspensor generally elongate towards the chalaza but in genera like *Phalaenopsis* and *Diplocentrum,* the individual cells may elongate towards the micropylar end also and the tubes branch out in all directions.

TYPE *V*. The early divisions in the zygote result in the formation of an irregular mass of 6-10 cells. Many of these situated nearer to the micropylar end begin to elongate immediately, whereas a filamentous proembryo develops from an un-elongated cell. The final form of the elongated cells is usually tubular. The nucleus of the suspensor cells become hypertrophied and the cells themselves show considerable accumulations of some granular and oily substances. The number of cells that elongate varies from 3 to 8 in many of the genera.

Table II brings together all the orchid genera whose suspensor organization is known. The type of suspensor is also indicated against the genera. The sequence of the tribes and genera in the table is according to the scheme of Pfitzer (1899).

TABLE II showing orchid genera whose suspensor organization is known.

Tribes and genera	Author	Type of suspensor
DIANDRAE		
Cypripedium reginae	Schnarf, 1931	Suspensorless
C. venustum	Treub, 1879	I
C. barbatum	Treub, 1879	I
C. spectabile	Treub, 1879	Suspensorless
MONANDRAE		
Ophrydinae—Serapiadeae		
Ophrys	Chodat, 1913	II
Orchis	Treub, 1879	II
Serapias	Treub, 1879	II
Himantoglossum	Heusser, 1915	II
Anacamptis	Treub, 1879	II
Ophrydinae—Gymnadenieae		
Herminium	Treub, 1879	II
Gymnadenia	Ward, 1880	II
Platanthera	Treub, 1879	II
Ophrydinae—Habenarieae		
Habenaria	Swamy, 1946c	II
Peristylus	Present study	II
Ophrydinae—Satyrieae		
Satyrium	Swamy, 1944	II
Ophrydinae—Corycieae		
Pterigodium	Duthie, 1915	II
Neottiinae—Vanilleae		
Vanilla	Swamy, 1947	I

TABLE II (*continued*)

Tribes and genera	Author	Type of suspensor
Neottiinae—Cephalanthereae		
Epipactis	Treub, 1879	I
	Brown and Sharp, 1911	I
Neottiinae—Gastrodieae		
Gastrodia	Kusano, 1915	I
Neottiinae—Spiranthеae		
Spiranthes	Leavitt, 1901	Suspensorless
	Swamy (unpublished data)	Suspensorless
Listera	Treub, 1879	Suspensorless
	Pfitzer, 1899	Suspensorless
Neottia	Dumee, 1910	Suspensorless
Neottiinae—Physureae		
Goodyera	Treub, 1879	I
Coelogyninae		
Coelogyne	Present study	I
Liparididinae		
Corallorrhiza	Leavitt, 1901	A variation of type I
Laeliinae		
Epidendrum	Sharp, 1912	III
	Treub, 1879	III
	Swamy, 1948a	III
	Present study	III
Sobraliinae		
Sobralia	Treub, 1879	III (very likely)
Phajinae		
Phajus	Sharp, 1912	I
	Treub, 1879	I
Spathoglottis	Present study	I
Peristeria	Present study	I
Aplectrum	Leavitt, 1901	A variation of type I
Cyrtopodiinae		
Geodorum	Present study	V
Eulophia	Swamy, 1943	V
	Present study	V
Dendrobiinae		
Dendrobium	Pastrana and Jose, 1931	I
	Present study	I
Bulbophyllinae		
Bulbophyllum	Present study	I
Cymbidiinae		
Cymbidium	Swamy, 1942a	V
Sarcanthinae		
Diplocentrum	Present study	IV
Luisia	Present study	IV
Cottonia	Present study	IV
Saccolabium	Present study	IV
Aerides	Present study	IV
Rhynchostylis	Present study	IV
Vanda	Swamy, 1942b	IV
Phalaenopsis	Treub, 1879	IV

The above table brings out the striking feature that specific tribes of the family exhibit only certain of the type of suspensor organization. Thus, suspensorless embryos occur largely in the tribes Cyrpipedilinae and Neottiinae; embryos with I type of suspensor in Phajinae and Dendrobiinae; type II in Ophrydinae; type III in Laeliinae and Sobraliinae; type IV in Sacranthinae and type V in Cyrtopodiinae and Cymbidiinae. The value of this remarkably consistent behavior will be taken up again on a subsequent page.

The suspensor of the type seen in the members of the tribe Ophrydinae are typically haustorial. The free cell of this organ gets imbedded in the placental tissue (type II), where the cell sends out lobed processes and exhibits all the characters of an aggressive haustorium. On the other hand, in the majority of other types of suspensors a true haustorial feature is open to question. Because, these suspensors, however elaborate they may be, do not go out of the seed cavity, nor do they reach any other nutritive zones (types I, III, IV, V). However, the nuclei of the suspensor cells of these types get slightly hypertrophied and many a time, the cells show conspicuous accumulations of lipoidal and other granular substances; further, the cell wall remains very thin. Although the function of these suspensors is also connected with the nutrition of the embryo, the actual mode of activity should be very different from the suspensors of the type II. Until sufficient evidence is brought forward by histological and physiological studies to point to the identical method of activities of the two categories, it seems desirable to designate the type II as "aggressive" and the types I, III, IV and V as "absorptive" haustoria.

5. CLASSIFICATION OF THE ORCHID EMBRYOS

The difficulties one has to face in attempting a classification of the embryos of orchids may be best expressed in the following words of Dr. D. A. Johansen (Plant Embryology, unpublished): ". . . too little is known of the sequence of cell divisions in the late proembryo and the early embryo. Matters are greatly complicated by the fact that no histogens save the epidermis are easily identified at the time the embryo is mature. There is also no definite resting period for most orchid seeds." Thus the characters that can be considered with reasonable confidence in attempting a classification become very much limited. Dr. Johansen continues, "Until such a time as a large number of species are carefully investigated and the exact sequence of divisions determined, it appears to be better to follow a different procedure for the orchidaceous embryos." On the basis of the "presence or absence of embryonal tubes and whether the latter arise directly or indirectly from the suspensor initial cell," Dr. Johansen recognizes 13 Patterns.

In general, Dr. Johansen's Patterns seem to have been recognized on slender characters and his scheme does not take into consideration the facts from ontogeny.* Many of the features cited by Dr. Johansen fall within the range of variations, often within a species. For example, (1) *The number of embryonal tubes.* Their number varies within a species, often within the

* See Swamy, 1948, for further remarks.

ovules of one and the same ovary as in *Cymbidium, Eulophia* and *Geodorum*. In all these genera the number of such cells fluctuates between 3 and 8. (2) *Embryonal tubes growing in all directions* and in *one direction only* and those *extending behind the embryo*. This character may be consistent with suspensors of the types I and II; but with other types, IV and especially V, it does not work. (3) The number and shape of the *terminal cells of the suspensor that extend out of the micropyle*. The utility of this character becomes very much narrowed down when one considers the variation reported in the same genus, such as *Phajus* (Treub, 1879 and Sharp, 1912), *Habenaria* (Leavitt, 1901 and Swamy, 1946c), etc.

It may further be observed that his treating *Cymbidium* and *Eulophia* as belonging to separate Patterns, the Patterns having been designated after their respective names, does not seem to be justified as they have identical ontogenetic sequences and mature organizations. Again, Dr. Johansen has created separate Patterns for *Vanda* and *Phalaenopsis*. Many of the characters exhibited by species of *Phalaenopsis* during ontogeny strikingly parallel the situation in *Vanda*. The differentiation of the branching system of *Phalaenopsis* suspensor is only a modification of what is seen in the other members of Sarcanthinae, through genera like *Diplocentrum*, where we see the initiation of the branching and micropylar elongation of the suspensor cells.

It has been shown on the preceding pages that the embryogeny of orchids may be divided into the Asterad, Onagrad and Cymbidium forms and that apart from the suspensor-less embryos, five fairly compact types of suspensor organizations may be recognized, the basis of the recognition of the types being both their ontogeny and mature organization. Making use of all these characters, a provisional scheme of classification of the orchid embryos may be presented in the form of the following key. The designation of the type of embryogeny by the corresponding generic names does not seem to be a sound procedure in this family, because of the complications involved in the question of priority in selecting the type genus and also because of the considerable range of variations within the types as conceived in the present study. Hence the respective types will be referred to by alphabets, as A, B, C, etc., including those well-recognized general types (Schnarf, 1929; Johansen, 1945).

KEY

1. Wall in the basal cell transverse and that in the terminal cell longitudinal 2
   Wall in the basal and terminal cells during second to fourth cell generations with no definite pattern. Prosuspensor cells differentiated first and a filamentous proembryo only later (Cymbidium form) ....Type F. (CYMBIIDIINAE, CYRTOPODIINAE)
2. Suspensor present and is developed from the suspensor initial cell 3
   Suspensor absent. The suspensor initial cell also divides and contributes to the embryonal mass proper (Asterad type) .....
   .....Type A. (CYPRIPEDILINAE, NEOTTIINAE, in part)
3. Suspensor initial cell undergoes divisions to produce the suspensor and as such is multicellular 4
   Suspensor initial cell directly functions as the suspensor and as such is single celled (suspensor type I), (Onagrad type) .....
   .....Type B. (PHAJINAE, DENDROBIINAE)

4. Suspensor generally does not extend or elongate beyond the limits of the seed coat 5

Suspensor as a rule elongates out of the seed coat, and the free cell of the suspensor gets imbedded in the placenta; all divisions in the suspensor initial cell transverse (suspensor type II), (Onagrad type) ..... Type C. (OPHRYDINAE)

5. Divisions in the suspensor initial cell first transverse and subsequently oblique and vertical; the individual cells do not elongate to any great dimension, but slightly bulge (suspensor type III), (Onagrad type) ..... Type D. (LAELLINAE, SOBRALIINAE)

Divisions in the suspensor initial cell vertical only. Individual cells elongate to comparatively enormous lengths; cells branching or not; elongation chiefly toward chalaza or towards the micropyle also (suspensor type IV), (Onagrad type) ..... Type E. (SARCANTHINAE)

6. POLYEMBRYONY AND APOMIXIS

Recently several competent reviews on polyembryony and apomixis in angiosperms have been published (Webber, 1940; Stebbins, 1941; Gustafsson, 1946, 1947), and it is not pertinent at present to enter into any detailed discussions. Here, only an attempt is made to bring together the available information concerning these two phenomena in orchids.

Of the orchids included in the Table III, *Spiranthes, Zeuxine* and *Nigritella* exhibit a high percentage of polyembryonate seeds and the number of embryos per seed is also fairly high, one to six. Furthermore, these orchids are known to be apomicts wherein the sexual method of reproduction is suppressed. All the embryos in *Spiranthes* arise from the innermost layer of cells of the inner integument; in *Zeuxine* and *Nigritella,* from the nucellar epidermis. The high percentage of polyembryonate seeds in these species is obviously connected with the agamospermic behavior of the plants.

The remainder of the orchids are all primarily sexual forms, exhibiting polyembryony only once in a way. In most cases, the polyembryonate seeds contain not more than two embryos. In *Habenaria platyphylla, Eulophia* and *Cymbidium,* the additional embryo takes its origin from the sexually produced embryo itself by a process of budding, proliferation or cleavage and thus the twin embryos are monozygotic. In *Gastrodia,* one of the synergids is reported to get fertilized in addition to the zygotic embryo. In *Epipactis,* Hagerup contends that two embryo sacs that are occasionally present in the same ovule get fertilized, so that the resulting embryos should be of different genotypes. In *Gymadenia* and *Pterigodium,* polyembryony is said to be due to the development of nucellar embryos in addition to the sexually produced one. In other orchids, the method of origin is not ascertained.

The factors that cause polyembryony are not fully understood. Ernst's (1918) view that hybridization brings about this phenomenon may be one of the factors in orchids. In 1901, Leavitt found that in the "supposed hybrid seed" obtained from the pollen of *Goodyera tessellata* upon *G. pubescens* "gave a much larger proportion of twins than the seed of either parent." Similar observations have also been made on *Zygopetalum* (Suessenguth,

1923). The studies of Dermen (1936) on apple, Kasparayan (1938) on wheat, Lamm (1938) on potato, Ramaiah and others (1935) on rice, etc., also support Ernst's view. However, this factor cannot be said to operate in orchids that are not hybrids.

Haberlandt's necrohormone theory as a cause of polyembryony has not

TABLE III.

Species showing polyembryony or apomixis	Author	Method of origin of adventive embryos	Number of embryos per seed
Cypripedium calceolus	Strasburger, 1878	not known	–
Spiranthes cernua	Leavitt, 1901	from the inner integument	2–6
	Swamy, unpublished data		
Goodyera tessellata, *G. pubescens*	Leavitt, 1901	not known	–
Orchis latifolia	Braun, 1860	not known	–
Gymnadenia conopsea	Strasburger, 1878	doubling of the egg and also nucellar	–
Aplectrum hiemale, *Habenaria tridentata*, *H. blephariglottis*	Leavitt, 1901	not known	2
H. platyphylla	Swamy, 1946c	monozygotic	2–4
Corallorrhiza multiflora	Leavitt, 1901	not known	2
Pterigodium Newdigatae	Duthie, 1915	not known	2, 3
Gastrodia elata	Kusano, 1915	from the egg or synergid	2
Zygopetalum Mackayi	Suessenguth, 1923	seems to be a partial apomict; embryos are said to arise in a variety of ways*	3
Zeuxine sulcata	Seshagiriah, 1941	from the nucellar epidermis	2–5
	Swamy, 1946		
Satyrium nepalense	Swamy, 1944	not known	2
Eulophia epidendraea	Swamy, 1943	monozygotic	2
E. nuda	present study	monozygotic	2
Geodorum densiflorum	present study	monozygotic	2
Vanilla planifolia	Swamy, 1947	not ascertained	2
Nigritella nigra	Afzelius, 1928, 1932	nucellar epidermal	–
Orchis maculatus	Hagerup, 1944	not known	2
Epipactis latifolia	Hagerup, 1945	probably by the fertilization of two embryo sacs in the same ovule	2

* See Gustafsson, 1946.

found much support in recent times (see Beth, 1938, Gustafsson, 1947). Especially in *Zeuxine* and *Spiranthes*, the asexual embryos begin developing even before the megaspore mother cell shows signs of degeneration and this situation makes Haberlandt's conception still more doubtful.

Further, in *Cymbidium* polyembryony occurs to the same degree in plants growing in a wild condition as well as in plants under long cultivation. In *Habenaria platyphylla*, the material collected from the natural habitat showed polyembryonate seeds quite often, whereas the same plants when brought under cultivation failed to exhibit the phenomenon. Twin embryos in seeds are by no means confined to apomicts and terrestrial orchids but are also seen in saprophytes like *Corallorhiza*, *Epipogum*, etc., (unpublished data of the author). All these facts make one suspect that the phenomenon in orchids is not the result of any one factor alone.

7. FRUIT

In all the epiphytic genera and species studied at present, the innermost cell layer of the ovary undergoes characteristic modifications after fertilization or even pollination. The development of heavily lignified hairs possessing remarkable hygroscopic property is one such common feature. Usually they originate in longitudinal rows in front of the median vascular bundles of the carpels. The number of rows vary with the genera. In the terrestrial orchids, the corresponding cell layer behaves in a different manner. The individual cells undergo great distension transversely, their wall becomes lignified and develops numerous slit-like pits. In *Vanilla*, the cells of this layer elongate and project into the ovary in the form of hairs, which are supposedly of secretory function.

The fruit of orchids is usually classified as a dry capsule, beaked by the remains of the perianth and gynostegium. It dehisces by six longitudinal splits forming three broad and three narrow valves which remain united at both ends. In *Angraecum*, the dehiscence is brought about only by one longitudinal slit; in *Pleurothallis*, by two; in *Lockhartia* and *Loptotis*, respectively by three and six valves, spreading downwards (Rendle, 1930). *Vanilla* offers the only instance in the family to have a fleshy fruit. The dehiscence is said to take place by means of two imperfectly defined longitudinal splits.

8. SEED

The seed structure of orchids is simple and highly characteristic. The outermost layer of the outer integument persists as the seed coat. During development, the cells of the outer integument lose their protoplasts and the walls become transparent. These changes give a reticulate appearance to the seed coat. In the terrestrial genera, the walls do not thicken or harden but may sometimes develop characteristic striations as in *Eulophia nuda*. On the other hand, in the epiphytic orchids the walls of the seed coat (especially the radial walls) become thick and hard, but still remain transparent.

Vanilla is a clear exception, though a similar structure of the seed coat

is reported to exist in *Apostasia, Adatcylus* and *Selenipedium* (Netolitsky, 1926).* As the details of structure in the latter three genera are extremely meagre, further discussion is not possible. In *Vanilla*, most of the inner and all of the outer integumental layers of cells persist in a somewhat crushed condition to form the seed coat; in addition, the outermost layer of the outer integument becomes sclerotic and absolutely opaque due to dark infiltrations inside the cells and their walls (Swamy, 1947).

III. Embryological Tendencies in the Orchidaceae and Embryological Formula

Certain morphological characters and trends of specializations have been the guiding factors for the systematic classification of the orchids. Some of the salient and at the same time generally well recognized tendencies are: (1) The transition from the terrestrial habit to the epiphytic habit (2) Structural specialization of the rostellum and gynostegium (3) Pollen-caudicle and fertilization relationships (4) Morphological specialization of the flower itself in relation to the insect visits.

A remarkable correlation exists between the above-mentioned tendencies and some embryological trends:

(1) In the more primitive members of the family, the pollen is in the form of free grains (eg. Cypripedilinae, some members of Neottiinae) or compound grains (eg. large number of Neottids). The next stage in the specialization of the pollen is the adherence of the compound grains into massulae (eg. Ophrydinae). The culmination of this tendency is seen in Pollinia (eg. Many members of the epiphytic genera).

(2) The interval between pollination and fertilization and that between fertilization and the first division of the zygote increases gradually from the terrestrial to the epiphytic genera.

(3) The development of the embryo seems to have had a definite plan, which, however, becomes greatly disturbed during the very early stages of ontogeny by the onset of divisions with no definite sequence. That it had a

---

* Recently I have had the opportunity of examining the mature seeds (from herbarium material) of the following species, which were made available to me by the kindness of Prof. Oakes Ames and Mr. Charles Schweinfurth of the Botanical Museum, Harvard University:

1. *Apostasia Wallachii* R. Br. Collected by Romos and Edano in Mindoro. No. 3926.
2. *Neuwiedia hollingeri* Rchb. Collected by J. J. Smith. No. 052.
3. *N. veratrifolia* Bl. No. Rahmat Si Toroes 149.
4. *Selenipedium Schlimi* Lindl. et Rchb. No. 7259.
5. *S. reticulatum* Rchb. No. 8045.
6. *S. Chica* Rchb. Collected at Panama by Powell. No. 258.

Of the above, I find that the items 1 to 3 and item 6 possess opaque and sclerosed seed coat. *Selenipedium Schlimi* and *S. reticulatum* exhibit a seed coat similar to that of the majority of orchids.

definite plan may still be seen only in the earlier tribes. In the more specialized members, the norm becomes upset still earlier in ontogeny.

(4) Suspensorless embryos are confined largely to the Cypripedilinae and Neottiinae (in part). These embryos precede those with unicellular suspensor. In the more specialized tribes, the unicellular suspensor becomes variously modified by different types of multicellular organizations.

(5) The development of endosperm is reported only in certain genera belonging to the tribes Cypripedillinae and Neottiinae; but not in any of the genera that are considered to be highly specialized. Thus the loss of endosperm seems to be a progressive trend.

(6) A many-layered, opaque and sclerotic seed coat is found only in certain genera of Cypripedilinae and possibly in some members of the Neottiinae. In the other tribes, its structure has become very typical and stereotyped, — single layered, transparent, soft.

(7) The development of hygroscopic hairs from the carpellary wall is not generally seen in the terrestrial genera but is universally found in the epiphytic ones.

Of the other tendencies that are seen independently in the different tribes may be mentioned, (1) A reduction in the number of divisions of the primary chalazal nucleus of the embryo sac, and (2) A diminution in the size of chalazal nuclei as early as the four-nucleate stage of the embryo sac.

EMBRYOLOGICAL FORMULA

The desirability of expressing the embryological characteristics of groups or families of flowering plants in some crisp formula and its applicability in taxonomic considerations have recently been appraised by Schnarf (1933), Maheshwari (1945) and Just (1946). While expressing the embryological formula for the Orchidaceae, it becomes necessary to slightly expand the general theme provided by Just. The additions proposed are as follows:

1. In this family, pollen grains are predominantly adhered together in some form or other. Such a feature in varying degrees also characterizes certain other angiospermous families such as the Winteraceae, Droseraceae, Asclepiadaceae, Mimosaceae, etc. In order to distinguish the free pollen from the united condition, I propose to bracket the letter P to mean the united condition.

2. Endosperm is characteristically absent in the Orchidaceae as also in the Podostemaceae. This is a feature that deserves to be included in the formula. I propose denoting the absence of this feature by putting a minus sign after E. The presence of endosperm may however be indicated as to its exact type (Ce, Nu, He) as suggested by Just.

3. It is frequently seen among angiosperms that the antipodals show an arrested development or an increased activity. These tendencies are seen

specifically in certain families and cannot be ignored. So I propose using the symbol /a> after mentioning the type of embryo sac when the number of antipodals is less than three, and the symbol /a< when they exceed three.

4. So far as the glandular or amoeboid anther tapetum is concerned, it is also desirable to express whether the cells of the tapetum are uninucleate, binucleate or multinucleate. Although the proper symbols for these characters are to be evolved after the cooperation of plant embryologists, I tentatively represent the features by employing /1, /11, and /* for denoting uni-, bi-, and multinucleate conditions respectively.

For reasons that will be obvious from the formulae themselves and also from the following pages, I propose giving two separate formulae, one for the major subdivision of the family Diandrae, and a second one for the other major subdivision Monandrae. After incorporating the additions suggested above for Just's scheme, the embryological formulae of the two subdivisions may be expressed as follows:

Diandrae.—Tg/11, Psi/2, $((Ov))\theta$ my/io, Nu_1 Ar, Esal/a>, Po, E–, Em (undifferentiated).

Monandrae.—Tg/1, (P)si/2, $((Ov))\theta$, my/io, Nu_1, Ar, Esn/a>, Po, E–, Emao (undifferentiated), Su.

The floral characters of the two subdivisions are also at variance with one another and the most important of these may be briefly summed up as follows for comparison:

Diandre.—Lateral sepals partially or completely fused. Gynostegium absent or extremely rudimentary. Lateral stamens of the inner whorl functional. Stigmas more or less free, the median one also being reecptive and not showing the transformation into rostellum.

Monandrae.—Lateral sepals free. Gynostegium well organized. Median stamen of the outer whorl functional. Stigmas confluent, the lateral ones being functional and the median one having undergone specialization into rostellum.

IV. SOME SYSTEMATIC CONSIDERATIONS

It has been shown on the preceding pages that a number of embryological trends such as, the modifications of pollen, suspensor, ovary wall and seed, etc., are generally in close correlation with the morphological trends of specialization of the plant and flower. The application of the embryological tendencies and features in a consideration of the interrelationships of certain tribes may now be illustrated with reference to two groups, whose position is a matter of debate in the different systems of classification.

Let us consider the tribe Vandae of Bentham and Hooker. According to these authors, the subtribes like Eulophieae, Cymbidieae, Cyrtopodieae, Stanhopieae, Sarcantheae, etc., have been grouped together under this tribe. The distinctive and constant embryological features of the first three subtribes may be summed up as follows (Fig. 47): (a) a reduction in the number of antipodal nuclei in the embryo sac (b) absence of a proembryo of 4 cells and 3 tiers during the second cell generation of the zygote and (c) possession of

the V type of suspensor. The corresponding features in the last two tribes, Stanhopieae and Sarcantheae, are as follows: (a) typically eight-nucleate embryo sac (b) presence of a proembryo of 3 tiers and 4 cells and (c) possession of IV type of suspensor. Upon taxonomic considerations, Pfitzer (1899) segregated the Sarcanthinae and accorded to the tribe a position far removed from the first four subtribes mentioned above. In fact, by some authorities (see Darwin, Rolfe, Pfitzer) the members of the Sarcanthinae are considered as terminating the monandrous line of orchids. In this regard it should be emphasized that the embryological evidence favors such a segregation as has been proposed by Pfitzer.

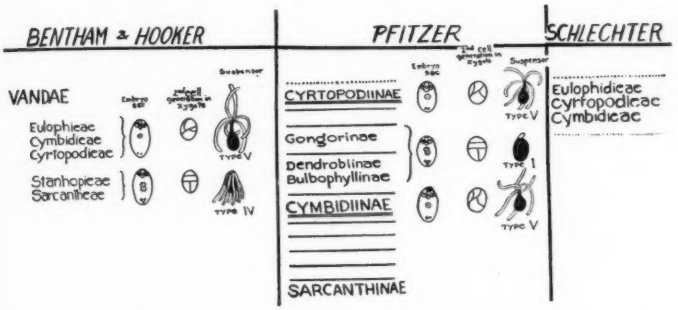


Fig. 47.—Diagrammatic representation of embryological features of certain of the tribes of the family, whose systematic positions are discussed in the text.

Thus, Pfitzer took the first step in treating the Sarcanthinae as a distinct group, far removed from its previous heterogeneous alliance. But one is apt to be sceptical about his treatment of the Cyrtopodiinae and Cymbidiinae (which include the genera of Eulophieae, Cymbidieae, Cyrtopodieae and Stanhopieae of Bentham and Hooker) in his system of classification. He has interposed seven other tribes such as the Gongorinae, Dendrobiinae and Bulbophyllinae, between the Cyrtopodiinae and Cymbidiinae (Fig. 47). All the embryological features when considered together do not favor such a wide gap between the closely related Cyrtopodiinae and Cymbidiinae. A comparison of the chief embryological features of the intervening tribes (like Gongorinae, Dendrobiinae and Bulbophyllinae) with those of the Cymbidiinae and Cyrtopodiinae (see last para) makes the point clear: (a) a typical eight-nucleate embryo sac (b) the presence of a 4-celled and 3-tiered proembryo during the second cell generation of a zygote and (c) possession of the I type of suspensor. Although Schlechter was not aware of the embryological data, his scheme of grouping Eulophideae, Cyrtopodieae and Cymbidieae together (Fig. 47), is a striking parallel to the embryological findings.

A knowledge of embryological characters further help us to evaluate and reconsider the position of certain larger groups within the family Orchidaceae. This will be illustrated here with reference to the groups Ophrydinae and

Neottiinae. Whether the Ophrydinae should follow or precede Neottiinae is a point which has not been determined finally. Leaving aside the system of Bentham and Hooker, who, in their system treat these two groups as the third and fourth tribes respectively, Pfitzer and Schlechter make the Neottiinae succeed the Ophrydinae. On the other hand, authorities like Rolfe think that from an evolutionary point of view the Ophrydinae should follow the Neottiinae. Though the embryological features do not claim to settle this dispute, certain ones are very significant and deserve the serious consideration of taxonomists.

The pollen in the Ophrydinae is in the form of massulae, a third step in specialization, whereas in the Neottiinae it is either free or as compound grains, i.e., first and second steps of specialization. The Ophrydinae possess the well developed and more specialized II type of suspensor, whereas all the members of the Neottiinae are either wholly suspensorless or possess a rudimentary expression of the simplest kind, I type. In the Ophrydinae the seed coat always consists of a single layer of cells, is transparent and membranous as in the majority of orchids; but in the members of the Neotiinae, we have scattered examples of a multilayered, opaque and highly sclerotic seed coat. Such a seed coat is usually found only in the relatively primitive orchids. In the Ophrydinae, endosperm has not been reported in any member, but in the Neottiinae we have a few scattered examples where there is an incipient development of endosperm. This feature looks to be a relic of an ancient character. Darwin, indeed, derives the entire Ophrydinae from a hypothetical member of the Neottiinae, which member is supposed to combine "most of the characters, but in a less developed state, of *Goodyera, Epipactis* and *Spiranthes*." According to Rolfe, the tribe "Ophrydinae follows Neottiinae quite naturally, for the flowers show a far higher degree of complexity." I would like to emphasize that the embryological features support hormoniously the views of Darwin and Rolfe in that the Neottiinae deserves to be considered as preceding the Ophrydinae.

Pfitzer (1899), Schlechter (1926) and Wettstein (1936) consider the pleurandrous orchids (*Apostasia, Adactylus, Neviedia, Cypripedium, Paphiopedium, Phragmopedium,* and *Selenipedium*) as the starting point to derive the other monandrous orchids. Hutchinson (1936), however, removes the first three genera and accommodates them under a separate family, the Apostasiaceae but maintains as other authors mentioned above, that the diandrous orchids are the progenitors of the Monandrae. On the other hand, Lindley (1840), Bentham (1881) and Hooker (1894) consider the diandrous orchids as succeeding the Monandrae. Rolfe (1909) does not agree with Pfitzer and his followers but thinks that the ophrydinae would be "certainly out of place" when it is made to follow the Diandrae.

Some of the salient morphological and embryological data do not seem to favor either the derivation of the Monandrae from the Diandrae or *vice versa*. It is difficult to assume that orchids with the two functional lateral stamens of the inner whorl have given rise to those with the single functional median stamen of the outer whorl, or the other way about. There are no intergrading forms to convince us of such an assumption. On the other

hand, the two major groups of the family seem to owe their derivation to some common ancestral stock.

In view of the current conflicting opinions as to the derivation of the family itself — whether from the general Liliaceous stock (Coulter and Chamberlain, 1912; Hutchinson, 1936) or from the Musaceae (Rendle, 1930) — it is not possible to say to which order the hypothetical ancestor should belong. However, pending this question, the hypothetical forms of orchids may be visualized as, " . . . terrestrial monocotyledons, with an inferior ovary, numerous minute seeds having a reticulated seed coat and rudimentary embryo; the stamens and pistils are not yet aggregated into a column. The flowers were doubtless fertilized by insects, which on visiting the former, would become dusted with the pollen grains from the anthers as in the case of other entomophilous monocotyledons. We may also infer that the ancestral orchids were natives of the great tropical region. The characters mentioned are found in the Malayan genus, *Newiedia*, the most primitive of the existing orchids. The species of *Newiedia* have short, erect stems, with a tuft of plicate, *Curculigo*-like leaves and an erect spike of yellow flowers, with nearly regular connivant perianth, and three linear or oblong anthers borne on one side of the flower, free pollen grains and a slender, nearly free style" (Rolfe, 1909). To these characters may also be added that the stamens were in two alternating whorls of three each, possibly with the lateral stamens of the outer and the median stamen of the inner whorls almost functionless. The endosperm development was also suppressed.

From such hypothetical forms, we may now trace the progressive modification of structure along two independent lines:

LINE A. The plants retained their terrestrial habit. Out of the three functional stamens (median one of the outer and the lateral two of the inner whorls), the median one of the outer whorl became functionless and persisted as a staminode, whereas the two lateral stamens of the inner whorl continued to function. The staminal and stigmatic vascular traces began to show fusion only to a very limited extent but did not proceed far; all the styles and stigmas continued to be functional (see Swamy, 1948b). Gradual transition of the trilocular ovary into an unilocular one became established. The pollen grains remained powdery but became embedded in a viscous fluid. Embryo sac developed according to the bisporic eight-nucleate method (Swamy, 1948c). Embryo failed to develop a suspensor or when present, was of a very rudimentary nature. This line of evolution was less successful and culminated in forms like *Cypripedium* and did not ramify further in the variety of individuals.

LINE B. This was a very successful and prolific line of evolution with profuse ramifications both with regard to the number of genera and species and variety of habit. Out of the three functional stamens, the median one of the outer whorl alone remained functional whereas the lateral stamens of the inner whorl became functionless and finally disappeared externally, but being represented internally only by their vascular supply. The vascular pattern of the flowers became progressively modified in conjunction with the

external specialization (Swamy, 1848b). The ovary became unilocular. Staminal and stigmatic vascular traces became fused in various ways in the newly acquired structure, the gynostegium. With the progressive modification of this structure, the median stigma also became specialized into the rostellum and only the lateral two stigmas remained functional. The seeds developed a highly transparent and reticulate coat. The free pollen grains became agglutinated progressively into compound grains and the still more complicated massulae and pollinia (Swamy, 1948c). The embryos developed a suspensor, which progressively became more and more elaborate. The plants, step by step succeeded in establishing an epiphytic mode of existence. This line culminated in forms of the tribe Sarcanthinae.

SUMMARY

The development of the embryo and suspensor, together with some of the associated post-fertilization changes in the ovule and ovary of about 25 species of orchids (belonging to 14 genera) are described.

Pollination data has been provided for nine genera and shown that when this is supplemented with the existing records, a reasonable correlation exists between the terrestrial to the epiphytic habit of the genera in that the period between pollination and fertilization increases. It has also been pointed out that the duration between fertilization and the first division of the zygote widens correspondingly.

Fertilization is porogamous and one male nucleus promptly enters into fusion with that of the egg. The fusion of the second male nucleus with that of the secondary embryo sac nucleus is not always complete; most usually all the components of the primary endosperm nucleus begin degeneration while still in the process of fusion.

The development of endosperm is totally suppressed. In those handful of instances where it does develop, is of the nuclear type. A brief mention is made of such instances.

Two fundamental methods of embryo development are recognized among the orchidaceous members: (1) The zygote gives rise to a linear row of three tiers and four cells and (2) The zygote gives rise to an undifferentiated mass of cells from which the suspensor cells are formed first and a filamentous proembryo later. The two types of development have been referred to as Group A and Group B respectively. A majority of the orchids follow the first method and only the members of the tribes Cyrtopidiinae and Cymbidiinae, the second.

The undifferentiated nature of the orchid embryos is indicated; attention is drawn to the fact that a regular pattern of development is overpowered by irregularity in the sequence and plane of cell divisions in the proembryo after the second cell generation of the zygote. In spite of these aberrations, however, the early divisions and the part played by the cells in the construction of the mature embryo give a clue to block out the types that are contemporarily recognized. — Asterad, Onagrad, etc.

The astonishing variety of the suspensor organization is described. According to the method of development and mature organization, five distinct types of suspensors are recognized in the family, in addition to the suspensorless forms. The genera in which the particular types occur are listed. It is shown that certain types of suspensors characterize only specific tribes of the family in general and it is suggested that this feature along with others may be of value for understanding the interrelationships of the tribes of the family.

After a consideration of the characters in the structure and development of the suspensor and embryo proper, an artificial key is proposed for the allocation of the orchid embryos.

It is further suggested that the orchid suspensors fall into two categories from a functional standpoint, — aggressive and absorptive.

A brief survey of the phenomena of polyembryony and apomixis in relation to orchids is presented. A short and comparative account of the seed structure is given and it is felt that in general the structure is uniform throughout the orchid genera, — only the outermost layer of cells of the outer integument persisting as the seed coat; it is transparent, thin and presents a reticulate appearance. Exceptions to this condition are also mentioned.

The development of hygroscopic hairs from the innermost cell layer of the ovary is described. An account of other modifications of the corresponding layer in the terrestrial orchids is also mentioned.

A section entitled, "Embryological tendencies in the Orchic'aceae and embryological formula," is devoted to briefly sum up the distinctive trends of embryological features of the family. The embryological formulae for the Diandre and Monandrae are given.

The sum total embryological characters of the tribes Vandae, Sarcanthinae, Dendrobiinae, Cyrtopodiinae and Cymbidiinae are considered in relation to their respective position in different systems of classification. The role of embryological characters in discussions concerning the systematic position of the tribes Ophrydinae and Neottiinae is illustrated. Finally, it is pointed out that it would not seem tenable to derive the Monandrae from the Diandrae or *vice versa*. Divergences in the embryological and floral characters between the two groups are stressed and it is suggested that the two groups have originated from some common stock. The characters of such hypothetical members and the probable lines of evolution that have resulted in the Diandrae and Monandrae are described.

ACKNOWLEDGEMENTS

I am very grateful to Dr. P. Maheshwari for his unfailing interest and assistance during the preparation of this paper. However, I do not hold him responsible for the statements and views expressed. I thank Dr. D. A. Johansen for his generosity in making available to me the pertinent parts of orchid embryology from his unpublished manscript and for allowing me to make use of the same. I am much obliged to Prof. Oakes Ames and Mr. Charles Schweinfurth for allowing me to make use of the library and orchid herbarium of the Botanical Museum. I have no means of adequately expressing my gratitude to Prof. I. W. Bailey for his kind encouragement and understanding.

REFERENCES

AFZELIUS, K. 1916—Zur Embryosackentwicklung der Orchideen. Svensk Bot. Tidskr. 10: 183-227.

———1928—Die Embryobildung bei *Nigritella nigra*. Ibid. 82-91.

———1932—Zur Kenntnis der Fortpflanzungsverhältnisse und Chromosomenzalhen bei *Nigritella nigra*. Ibid. 26: 365-369.

BENTHAM, G. 1881—Notes on Orchidaceae. Jour. Linn. Soc. Bot. 18: 281-360.

BETH, K. 1938—Untersuchungen über die Austlösung von Adventivembryonic durch Wundreiz. Planta 28: 296-343.

BRAUN, A. 1860—Über Polyembryony und Keimung von *Caelebogyne*. Abh. Ak. Berlin, Phys. Kl. 1859. 109-263.

BROWN, W. H. AND L. W. SHARP 1911—The embryo sac of *Epipactis*. Bot. Gaz. 52: 439-452.

CHODAT, R. 1913—*L'Ophrys Botteroni* Chod., est-il éspèce en voie de formation? Bull. Soc. bot. Genève, 2 sér., 5: 13-28

COULTER, J. M. AND C. J. CHAMBERLAIN 1912—Morphology of Angiosperms. Chicago.

DARWIN, C. 1879—The Various Contrivances by which Orchids are fertilized by Insects. London.

DERMEN, H. 1936—Aposporic parthenogenesis in a triploid apple, Malus hupehensis. Jour. Arnold Arb. 17: 90-105.

DUMEE, P. 1910—Quelques observations sue l'embryon des Orchidees. Bull. soc. bot. France 57: 83-87.

DUTHIE, A. V. 1915—Note on apparent apogamy in *Pterigidium Newdigatae*. Trans. R. Soc. South Africa 5:593-598.

ERNST, A. 1918—Bastardierung als Ursache der Apogamie in Pflanzenreich. Jena.

GUIGNARD, L. 1886—Sur la pollinisation et ses effects chez les Orchidees. Ann. sc. nat. Bot. 7 sér. 4: 202-240.

GUSTAFSSON, A. 1946—Apomixis in higher plants. Part I. The mechanism of Apomixis. Lunds Univ. Arsskr. 2: 1-66.

———1947—Apomixis in higher plants. Part II. The casual aspect of apomixis. Ibid. 2: 71-178.

———1947—Apomixis in higher plants. Part III Biotype and species formation. Ibid. 2: 183-370.

HAGERUP, O. 1944—On fertilization, polyploidy and haploidy in *Orchis latifolia*. Dansk Bot. Arkiv 11. No. 5: 1-25.

———1945—Facultative parthenogenesis and haploidy in *Epipactis latifolia*. Kgl. Danske Vidensk. Selsk. Biol. Medd. Bd. 19. No. 11: 1-14.

HEUSSER, K. 1915—Die Entwicklung die generativen Organe von *Himantoglossum hircinum*. Beih. bot. Centralbl. 32: 218-277.

HOOKER, J. D. 1894—Flora of British India. London.

HUTCHINSON, J. 1936—The Families of Flowering Plants, Vol. II Monocotyledons. London.

JOHANSEN, D. A. 1945—A criitcal review of the present status of plant embryology. Bot. Rev. 11: 87-107.

JUST, T. 1946—The use of embryological formulas in plant taxonomy. Bull. Torrey Bot. Club 73: 351-355.

KASPARAYAN, A. S. 1938—Haploids and haplo-diploids among hybrid twin seedlings in wheat. Compt. Rend. Acad. Sci (Doklady). U.S.S.R. 20: 53-56.

KUSANO, S. 1915—Experimental studies on the embryological development in an angiosperm. Jour. Coll. Agri. Univ. Tokyo 6: 7-120.

LAMM, R. 1938—A contribution to the embrology of the potato. Svensk Bot. Tidskr. 31: 217-220.

LEAVITT, R. G. 1901—Notes on the embryology of some New England Orchids. Rhodora 3: 61-63; 202-205.

LINDLEY, J. 1840—The Genera and Species of Orchidaceous plants. London.

MAHESHWARI, P. 1945—The place of angiosperm embryology in research and teaching. Jour. Indian Bot. Soc. 24: 25-41.

NETOLITSKY, F. 1926—Anatomie der Samen. Berlin.

PACE, L. 1907—Fertilization in *Cypripedium*. Bot. Gaz. 44: 353-374.

PASTRANA, M. D. AND K. S. JOSE 1930—A contribution on the life history of *Dendrobium anosum* Lindley. Nat. & Appl. Sci. Bull. (Philippines) 1: 133-144.

PFITZER, E. 1899—The Orchidaceae in Engler and Prantl, Die natürliche Pflanzenfamilien.

PROSINA, M. N. 1930—Über die von *Cypripedium*-Typus abweichende Embryosackentwicklung von *Cypripedium guttatum* Sw. Zeitschr. Wiss. Biol. Planta 12: 532-544.

RAMIAH, K., N. PARTHASARATHI, AND S. RAMANUJAM 1935—Polyembryony in rice (*Oryza sativa*). Indian Jour. Agri. Sci. 5: 119-124.

RENDLE, A. B. 1930—The Classification of Flowering Plants. Vol. I. Monocotyledons. London.

ROLFE, R. A. 1909—The evolution of the Orchidaceae. Orchid Rev. (several discontinuous pages of the issues of 1909 to 1912).

SCHLECTER, R. 1926—Das System der Orchidaceen. Notiz. des Bot. Gart. u. Mus. Berlin-Dehlem. Bd. 9, No. 88: 563-591.

SCHNARF, K. 1929—Embryologie der Angiospermen. Berlin.

———1931—Vergleichende Embryologie der Angiospermen. Beriln.

———1933—Die Bedeutung der embryologischen Forscung fur das natürliche System der Pflanzen. Biol. Gener. 9: 271-288.

SESHAGIRIAH, K. N. 1941—Morphological studies in the Orchidaceae I. *Zeuxine sulcata* Lindley. Jour. Indian Bot. Soc. 20: 357-365.

SHARP, L. W. 1912—The orchid embryo sac. Bot. Gaz. 54: 373-385.

STEBBINS, G. L. 1941—Apomoxis in Angiosperms. Bot. Rev. 7: 507-542.

STRASBURGER, E. 1878—Über Polyembryonie. Jenaische Zeitschr. 12: 647-670.

SUESSENGUTH, K. 1923—Über die Pseudogamie bei *Zygopetalum Mackayi* Hook. Ber. d. deutsch. bot. Ges. 41: 16-23.

SWAMY, B. G. L. 1942a—Female gametophyte and embryogeny in *Cymbidium bicolor* Lindl. Proc. Indian Acad. Sci. B. 15: 194-201.

———1942b—Morphological studies in three species of *Vanda*. Curr. Sci. 11: 285.

———1943—Gametogenesis and embryology of *Eulophia epidendraea* Fischer. Proc. Nat. Inst. Sci. India 9: 59-65.

———1944—The embryo sac and embryo of *Satyrium nepalense* Don. Jour. Ind. Bot. Soc. 23: 66-70.

———1946a—The embryology of *Zeuxine sulcata* Lindl. New Phytol. 45: 132-136.

———1946b—Some notes on the embryo of *Cybidium bicolor* Lindl. Curr. Sci. 15: 139-140.

———1946c—Embryology of *Habenaria*. Proc. Nat. Inst. Sci. India 12: 413-426.

———1947—On the life history of *Vanilla planifolia*. Bot. Gaz. 108: 449-456.

———1948a—Embryology of *Epidendrum prisimatocarpum*. Bull. Torrey Bot. Club 75: 245-249.

———1948b—Vascular anatomy of orchid flowers. Under publication in the Leaflets of the Botanical Museum, Harvard University.

———1948c—Embryological studies in the Orchidaceae. I. Gametophytes. In Press.

TREUB, M. 1879—Notes sur l'embryogénie des quelques Orchidées. Verh. Akad. Amsterdam, Natuurk. 19: 1-50.

WARD, H. M. 1880—On the embryo sac and development of *Gymnadenia conopsea*. Quart. Jour. Microsc. Sci. 20: 1-18.

WEBBER, J. M. 1940—Polyembryony. Bot. Rev. 6: 575-598.

The Resin Sac Pattern in the Needles of Engelmann Spruce and Blue Spruce from Southeastern Wyoming[1]

John F. Reed and George F. Freytag
University of Wyoming, Laramie

The difference in the number of resin ducts in a cross-section of the needle has been considered by several authorities (Sargent, 1898; Sudworth, 1916; Preston, 1940) to be a reliable specific characteristic for distinguishing between Engelmann spruce (*Picea Engelmanni* (Parry) Engelm.) and blue spruce (*Picea pungens* Engelm.). Others have been more cautious concerning the significance of this characteristic. Sharp (1915) indicated that he had experienced difficulty in procuring sections of the needles of either of these species which showed resin ducts. Durrell (1917) avoided the use of the numbers of resin ducts as positive criteria of differences between these two species, but stated that one or both ducts may be missing from Engelmann spruce needles, whereas blue spruce usually has two. Both Sargent (1933) and Harlow and Harrar (1941) refrain from using the resin ducts of the needles in their treatment of these species of spruce.

In 1931 Marco seemed to have settled the situation with respect to numbers of resin cavities in the needles of these two spruces. He made two major contributions: (1) that the resin-containing units were not of the usual type found in the genus *Pinus*, but rather a longitudinal series of short cysts or sacs separated from each other by transverse partitions of mesophyll; and (2) that both Engelmann spruce and blue spruce contain two of these longitudinal series of sacs in the base of their needles, but only in the latter does either one or both of these series extend into the upper half of the leaf. Such cysts or sacs were recognized by Penhallow (1907) as characteristic of the wood of *Picea* as well as of that of five other coniferous genera. He does not mention the anatomy of the leaves.

The terms cyst, sac, resin passage, and resin duct have all been used with reference to the cavities surrounded by resin-secreting cells in the conifers. We have chosen to refer to these units in spruce needles as resin sacs, because the term seems least ambiguous and conveys the impression of a relatively short, discontinuous unit in contrast with the long, continuous type of resin duct in the needles of the pines.

In view of our field experience which seemed at variance with the statements on the subject in the literature, and because Preston (1940) continued the use of the number of resin ducts as a characteristic having taxonomic value in separating these two species of spruce, even after Marco's contribution some nine years earlier, we were motivated to investigate the situation from material collected in Albany County near Laramie, Wyoming.

1 Contribution Number 211 from the Department of Botany and the Rocky Mountain Herbarium of the University of Wyoming.

MATERIAL AND METHODS OF STUDY

One thousand needles from ten trees of Engelmann spruce and the same number from ten trees of blue spruce were collected from the campus of the University of Wyoming and from the foothills of the Laramie Range at elevations of approximately 7200 and 8200 feet above sea-level respectively. These thousand-leaf samples were taken during the winter of 1947-48 and studied while fresh. Each composite sample included needles from trees of different ages as well as needles of various ages from the same trees.

After some preliminary work with hand-sectioned material, we were able to distinguish the resin sacs in their entirety through the surface of unsectioned fresh needles with the aid of a dissecting microscope. Throughout the study we subjected this technique to careful checking by making frequent hand-sections. The resin sacs were consistently external in the lateral angles of the needles. No internal, branched, or otherwise obscure sacs were found in a single one of the hundreds of hand-sections made.

Measurements of the length of both whole needles and resin sacs were made, and the number of resin sacs in whole leaves as well as the number in the upper, middle, and basal thirds of each leaf was determined. The position of the resin sacs was noted with respect to the orientation of each needle on its twig. Identical measurements, counts, and observations were carried out on both species of spruce.

RESULTS

The results of the determination of the length of needles and resin sacs as well as the total number of sacs per needle of each species are shown in Table I.

TABLE I.—Averages and variations of the length of needles, length of resin sacs, and number of resin sacs per leaf of Engelmann spruce and blue spruce based on one thousand fresh leaves of each species from trees growing in Albany County, Wyoming. Probable errors of means are included.

	Engelmann Spruce	*Blue Spruce*
Needle length		
Mean and probable error	15.7 mm. ± 0.69	16.2 mm. ± 0.56
Minimum	10.0	12.0
Maximum	20.0	20.0
Resin Sac length		
Mean and probable error	1.6 mm. ± 0.28	5.3 mm. ± 0.23
Minimum	1.0	3.0
Maximum	3.0	7.0
Resin Sacs per leaf		
Mean and probable error	1.4 ± 0.17	3.7 ± 0.52
Minimum	0	1
Maximum	4	5

From an actual count of the resin sacs in the various regions of the leaf it was found that considerable variation between the species exists. In the

upper third of the needle the average number of sacs was 0.008 per needle for Engelmann spruce and 1.4 for blue spruce; in the middle third 0.3 and 1.1; and in the basal third 0.7 and 1.5 respectively.

The frequency of the occurrence of two sacs, one sac, and no sacs in each longitudinal portion of the needles is shown in Table 2. The figures are expressed as the proportionate number of times that each condition exists in each one hundred leaves (per cent) of the thousand-needle sample for each of the species.

TABLE 2.—The frequency (F) of the occurrence of two resin sacs, one resin sac, and no resin sacs in the upper, middle and basal thirds of the needles of Engelmann spruce and blue spruce. Data based upon one thousand fresh leaves of each species from trees growing in Albany County, Wyoming.

Position along needle	Two sacs F per cent	One sac F per cent	No sacs F per cent
		Engelmann Spruce	
Upper third	0.0	0.8	99.2
Middle third	14.5	19.9	65.6
Basal third	25.0	21.3	53.7
		Blue Spruce	
Upper third	55.1	24.8	20.1
Middle third	36.7	40.5	22.8
Basal third	58.5	27.8	13.7

INTEGRATION AND SUMMARY

The resin sacs of both Engelmann spruce and blue spruce are consistently found lying along the lateral angles of the needles. They are arranged in longitudinal series interrupted by transverse partitions of mesophyll. The average number of resin sacs per needle is nearly three times as great in blue spruce as in Engelmann spruce, and in the former the average resin sac is somewhat more than three times as long as in the latter species. Resin sacs were found to be entirely wanting in a few needles of the Engelmann spruce, a condition never encountered in blue spruce. Needles of the two species are not appreciably different in total length.

It is most unusual to find a resin sac in the upper third of an Engelmann spruce needle in our region, but over half (55.1 per cent) of the blue spruce needles have two sacs and over three-fourths (79.9 per cent) have at least one sac in the same upper third. About one-third (34.4 per cent) of the needles from Engelmann spruce and over three-fourths (77.2 per cent) of those from blue spruce possess one or more resin sacs in their middle third. In the basal third of Engelmann spruce needles more than one-third (46.3 per cent) of the needles studied had one or more sacs as compared with blue spruce which had one or more sacs in over four-fifths (86.3 per cent) of its needles in this basal region.

It appears evident that there is a much greater chance of at least one

resin sac showing in a cross-section of a needle selected at random from blue spruce than from Engelmann spruce. It must have been such chance sampling which has led to the confusion regarding the reliability of the resin-sac characteristic in the taxonomy of these species.

These data reveal that there is suffiicent variation in the number of resin sacs in each region of the needle in either species to make resin sac disposition of dubious value in distinguishing between blue spruce and Engelmann spruce.

When it is realized that a single random cross-section through a needle which might be made at any position from base to tip could pass through the mesophyll partitions between the resin sacs, it becomes increasingly evident that the use of resin sacs in cross sections of needles should not be relied upon for the purpose of positive identification.

The usefulness of Marco's (1931) conclusion that normally the resin sacs are wanting in the upper half of Engelmann spruce, but one or more are invariably present in blue spruce is questionable in our region, for although 992 of the thousand Engelmann spruce needles studied were found without resin sacs in their upper thirds, one-fifth (20.1 per cent) of the needles of blue spruce also lacked sacs in the same region. Even in the middle third more than one-fifth (22.8 per cent) of the blue spruce needles had no sacs, whereas over 30 per cent of our Engelmann spruce needles had one or two resin sacs per cross-section above their basal third.

It would seem from this study that the one resin-sac characteristic which might be of diagnostic value is the relative length of the resin sac rather than the frequency of the occurrence of the sacs. The blue spruce resin sac varies from 3 mm. to 7 mm. in length and that of Engelmann spruce from 1 mm. to 3 mm. in fresh leaves.

This study suggests the desirability for a more extended study of the resin sac pattern in Engelmann spruce and blue spruce needles throughout the entire region where the ranges of these species overlap.

REFERENCES

DURRELL, L. W. 1917—Notes on some North American conifers based on leaf characters. Proc. Iowa Acad. Sci. 24: 519-582.

HARLOW, W. M. AND E. S. HARRAR 1941—Textbook of Dendrology. McGraw-Hill Book Company, Inc., New York.

MARCO, H. F. 1931— Needle structure as an aid in distinguishing Colorado blue spruce from Engelmann spruce. Bot. Gaz. 92: 446-449.

PENHALLOW, D. P. 1907—A Manual of the North American Gymnosperms. Ginn and Company, Boston.

PRESTON, R. J. 1940—Rocky Mountain Trees. Iowa State College Press, Ames.

SARGENT, C. S. 1898—The Silva of North America 12: 43-50. Houghton, Mifflin Company, New York.

———1933—Manual of the Trees of North America. Houghton, Mifflin Company, Boston.

SHARP, S. S. 1915—Notes on the determination of Rocky Mountain conifers. Torreya 15: 1-8.

SUDWORTH, G. B. 1916—The spruce and fir trees of the Rocky Mountain region. U. S. Dept. Agric. Bull. 327.

Taxonomy and Distribution of N. American Cat-tails

Neil Hotchkiss and Herbert L. Dozier

U. S. Fish and Wildlife Service
Laurel and Cambridge, Md.

Introduction

The Montezuma Marshes in central New York are dominated by hundreds of acres of cat-tails, of which there are three distinct kinds. These are called soft flag, blue flag, and nail rod. The name of the first presumably is from the texture of its leaves, the second from the color of its leaves, the third from its slender, hard stem. Two pioneer industries, muskrat farming and the cutting of flags for chair seating and barrel caulking material, are responsible for the names.

For a long time the Montezuma trappers have known that muskrats ate blue flag (*Typha angustifolia*, var. *elongata*) more than they did soft flag (*T. latifolia*), and each of these much more than they did nail rod (*T. angustifolia.*)[1] The first choice may be due to the greater abundance of blue flag; but the disregard for nail rod has some more fundamental reason.

1 Herbert L. Dozier, Sex ratio and weights of muskrats from the Montezuma National Wildlife Refuge. Jour. Wildlife Mgt. 9: 235. 1945.

Fig. 1.—*Typha latifolia* growing under optimum conditions in a swale at New Castle, Delaware, August 8, 1947.

The flag cutters, likewise, recognize differences. Nail rod is too brittle and small to be of use to them. Soft flag leaves, cut in July and August, are used for chair seats. Blue flag sheaths are harvested in the fall, after growth has stopped, for use in caulking barrels. The cutters can readily tell the three kinds of cat-tails by the appearance of the cross sections of their butts, or non-fruiting shoots.

Between 1946 and 1948 the writers studied cat-tails in the field from Florida to New York, and examined several hundred specimens from the National Museum, U. S. Forest Service, National Arboretum, U. S. Fish and Wildlife Service, Catholic University of America, University of Maryland, University of Pennsylvania, Philadelphia Academy, New York Botanical Garden, New York State Museum, Gray Herbarium, Cornell University, Syracuse University, University of Michigan, California Academy of Sciences and Florida Agricultural Experiment Station. Information was also obtained on specimens deposited at the University of Maine, University of Wyoming, and Willamette University. Above all, many botanists loaned, collected, and examined specimens, made helpful suggestions, or translated passages from European writings. Among these friends are Miss Lillian E. Arnold, Mr. William P. Baldwin, Dr. S. F. Blake, Dr. Russell G. Brown, Dr. W. H. Camp, Dr. Robert T. Clausen, Father Arthème Dutilly, Miss Elizabeth C. Earle, Dr. Norman C. Fassett, Dr. Mildred E. Faust, Prof. M. L. Fernald, Dr. John M. Fogg, Jr., Dr. F. J. Hermann, Dr. H. D. House, Mr. John Thomas Howell, Mr. E. P. Killip, Dr. Elbert L. Little, Jr. Mr. Bayard Long, Mr. John J. Lynch, Dr. Bassett Maguire, Dr. Rogers McVaugh, Dr. W. C. Muenscher, Dr. E. C. Ogden, Father Hugh T. O'Neill, Mr. W. D. Parker, Dr. Morton E. Peck, Dr. C. L. Porter, Mr. Paul G. Russell, Dr. Stanley Jay Smith, Dr. Robert R. Tatnall, Mr. F. M. Uhler, and Mr. Kenneth A. Wilson.

TYPHA GLAUCA

Since Linnaeus, two of the New York State cat-tails have been recognized as distinct. They are *Typha latifolia* and *T. angustifolia*. In 1886 Dudley in his Cayuga Flora[2] described the third as *T. latifolia* variety *elongata*.

Reworking the botany of the Cayuga Lake basin, Wiegand[3] observed that this third form resembled *angustifolia* more than it did *latifolia* and so renamed it *T. angustifolia* variety *elongata*. At the same time he referred two other published names to it as synonyms (variety *longispicata* Peck[4] and variety *virginica* Tidestrom[5]—but note beyond that the writers now refer the latter to the synonymy of *T. domingensis*). There the matter has rested,

2 William R. Dudley, The Cayuga flora. Bul. Cornell Univ. (Science) 2. Page 102. 1886.

3 K. M. Wiegand, Some changes in nomenclature. Rhodora 26: 1. 1924.

4 Charles H. Peck, Report of the State Botanist. *In* N. Y. State Museum: Forty-seventh annual report of the regents, for the year 1893. Page 162. 1894.

5 Ivar Tidestrom, The Typhae of Maryland and Virginia. Rhodora 13: 241-243. 1911.

except for suggestions by several students of local floras[6] that *T. angustifolia* variety *elongata* might be a hybrid of *angustifolia* and *latifolia*.

Meanwhile in Europe, where both *angustifolia* and *latifolia* are widespread, there was recognized as early as 1844 a cat-tail that Godron[7] called *glauca*. His description is as follows:

"T. glauca *Nob.*—Ressemble beaucoup pour le port au précédent [*T. latifolia*], mais s'en distingue â des caractères bien tranchés; le chaton femelle est d'un *roux chatain* et a un aspect *filamenteux*; le fruit est plus atténué aux deux extrémités, fusiforme; le stigmate est plus allongé, *linéaire-subulé*. On distinguera cette espèce du *T. angustifolia* aux caractères suivants: chaton femelle du double plus gros, plus allongé, contigu au chaton mâle; poils *tous insérés à la base du podocarpe*, tout à fait blancs et *d'une égale ténuité dans toute leur longeur* [*T. angustifolia*—axe cylindrique, muni de poils blancs, *spatulés-épaissis et colorés au sommet*]. Les feuilles sont glauques, planes, presque aiguës, larges d'un cent.; les tiges ont 12-15 décim. de hauteur."

Translated, this reads: Has much the appearance of the preceding [*T. latifolia*], but differs by sharply defined characters; the female spike is reddish chestnut and has a thready appearance; the fruit is more attenuate at the ends, fusiform; the stigma is more elongated, linear-subulate. This species is separated from *T. angustifolia* by the following characters: female spike twice as big, more elongated, contiguous to the male spike; hairs all inserted at the base of the stipe, perfectly white and equally thin throughout their length [*T. angustifolia*—axis cylindric, covered with white hairs, spatulate-thickened and colored at the tip]. The leaves are glaucous, flat, almost sharp, 1 cm. wide; the stems have a height of 12-15 dm.

In 1889 Kronfeld[8] monographed the genus, recognizing *Typha glauca* and giving his own described cross of *T. angustifolia* and *T. latifolia* as a synonym. The next year Figert[9] described a *latifolia-angustifolia* cross that had a space of intermediate length between the staminate and pistillate inflorescences. Ascherson and Graebner[10] redescribed Figert's hybrid as having a space of as much as 7 centimeters between the inflorescences and having the branches of the spikes dissimilar. They referred the *glauca* of the Godron and Kronfeld treatments to it as synonyms, although expressing doubt that the plant

---

8 M. Kronfeld, Monographie der Gattung *Typha* Tourn. (*Typhinae* Agdh., *Typhadanales*. Trans. Wis. Acad. Sciences, Arts, and Letters 25: 183-184. 1930.

Ada Hayden, A botanical survey in the Iowa lake region of Clay and Palo Alto Counties. Iowa State College Jour. Sci. 17: 357. 1943.

Clarence R. Hanes and Florence N. Hanes, Flora of Kalamazoo County, Michigan. Page 12. 1947.

7 D.-A. Godron, Flore de Lorraine. Vol. 3, page 20. 1844.

8 M. Kronfeld, Monographie der Gattung *Typha* Tourn. (*Typhinae* Agdh., *Typhaceae* Schur-Engl.). Verhandlungen der kaiserlich-koniglichen zoologisch-botanischen Gesellschaft in Wien 39: 89-192. 1889. *Glauca* on page 167. *T. elongata* (Dudley) Kronfeld given as a synonym of *latifolia* on page 176.

9 E. Figert, Botanische Mitteilungen aus Schlesien. III. Typha latifolia x angustifolia. Deutsche botanische Monatsschrift 8: 55-57. 1890.

10 Paul Ascherson and Paul Graebner, Synopsis der Mitteleuropaischen Flora. Vol. 1, page 278. 1896-98.

actually is a hybrid. Later, in his monograph of the family, Graebner[11] followed about the same course. So did Hegi[12] in his flora of central Europe. Godfrin and Petitmengin[13] figured *latifolia, angustifolia,* and *glauca.* Except for contiguous spikes, their figure of *glauca* is a good likeness of most American *angustifolia* variety *elongata.*

In 1946, 1947, and 1948 the writers observed and collected this cat-tail in each state from New York to Florida, except Pennsylvania; and F. M. Uhler, of the U. S. Fish and Wildlife Service, found it in Minnesota and South Dakota.

In March 1948 Hotchkiss saw at the Philadelphia Academy a specimen from Montpellier, France, which appeared to be identical with American plants seen in the field and in herbaria. *Typha glauca* in most respects is intermediate between *latifolia* and *angustifolia,* but its characters are definite and readily distinguished. Its American synonymy is as follows: *Typha glauca,* Godron, 1844; *T. latifolia* var. *elongata,* Dudley, 1886; *T. angustifolia* x *latifolia,* Kronfeld, 1889; *T. elongata,* (Dudley) Kronfeld,[8] 1889; *T. latifolia* x *angustifolia,* Figert, 1890; *T. angustifolia* var. *longispicata,* Peck, 1894; *T. elongata,* (Dudley) Durand & Jackson,[14] 1906; *T. angustifolia* var. *elongata,* Wiegand, 1924.

TYPHA DOMINGENSIS

Persoon[15] in 1807 based the binomial *Typha domingensis* on a West Indian cat-tail; while in 1815 Bonpland and Humboldt[16] described the same cat-tail from South America under the name *T. truxillensis.* As long ago as 1888, Morong[17] distinguished between *T. angustifolia* and *T. domingensis* in North America. In 1900 Graebner[11] also recognized their distinctness and reported the occurrence of *domingensis* in California, Texas, and Louisiana. Finally, in 1912, Gèze[18] described in detail *angustifolia, domingensis,* and *latifolia.* His descriptions and drawings included most of the characters detailed in the present paper. In spite of this recognition, *domingensis* has continued to be omitted from most of our floras, although regularly included in those covering areas from the West Indies southward.

---

11 Paul Graebner. Typhaceae. Das Pflanzenreich. IV. 8: 1-18. 1900. *Latifolia* x *angustifolia* on page 16. *Domingensis* on page 14. Relation of fertile and abortive flowers on page 6.

12 Gustav Hegi. Illustrierte Flora von Mittel-Europa. 2nd ed. Vol. 1, page 176. 1936.

13 Julien Godfrin and Marcel Petitmengin. Atlas de la flore analytique de la Lorraine et des contrées limitrophes. Page 11. 1913.

14 Theophilus Durand and B. Daydon Jackson. Index Kewensis Supplement I, page 442. 1906.

15 C. H. Persoon. Synopsis plantarum, Part 2, page 532. 1807. Starred entries are explained in Part 1, page x.

16 Aimé Bonpland and Alexander von Humboldt. Nova genera et species plantarum. Vol. 1, page 82. 1815.

17 Thomas Morong. Studies in the Typhaceae. I—Typha. Bul. Torr. Bot. Club 15: 1-8. 1888.

18 J.-B. Gèze. Études botaniques et agronomiques sur les Typha et quelques autres plantes palustres. 174 pages. 1912.

In the meantime Greene[19] discovered and described a giant cat-tail that he called *T. bracteata*. Morong[17] soon decided that this was only *domingensis*.

In 1911 Tidestrom[5] described *T. angustifolia* variety *virginica* from Maryland and Virginia. The Maryland plant was collected in early August, the Virginian in October. He described the pistillate spike of *angustifolia* as brown and that of variety *virginica* as cinnamon. He quoted from Kronfeld's[8] description of *T. angustifolia* x *latifolia* (*T. glauca* Godron), which the writers have identified with *T. angustifolia* variety *elongata*, and added: "As pointed out by Kronfeld this form has the habit and ebracteolate flowers of *T. latifolia*, and the color of the spike and form of the stigma of *T. angustifolia*. I have never observed any plant of the above description." The writers have been unable to locate Tidestrom's two original collections but have seen other collections of his that are labeled *Typha angustifolia* variety *virginica*. Some of these are *domingensis*, some are *glauca*.

In 1935 Fernald[20] reported the discovery of *T. truxillensis* near the Virginia-North Carolina line. Since that time Muenscher[21] wrote a manual that included this species. However, he did not clarify the fact that most of the southern cat-tails with separated spikes are this species, not *angustifolia*.

During 1946, 1947, and 1948 the writers confirmed in each state from Delaware to Florida the field characters that Fernald described. In herbaria they found specimens of *T. domingensis*—identified as *angustifolia*, *domingensis*, or *truxillensis*—from the southern half of the country, north as far as Utah, Kansas, and Delaware. Its American synonymy is as follows: *Typha domingensis*, Persoon, 1807; *T. truxillensis*, HBK., 1815; *T. bracteata*, Greene, 1887; *T. angustifolia* var. *virginica*, Tidestrom, 1911.

TYPHA ANGUSTIFOLIA

Roscoe,[22] in a study of Massachusetts material reported the occurrence of intermediates between *T. latifolia* and *T. angustifolia* and said that *angustifolia* shows hybrid characters. Calhoun,[23] in making a study of cat-tails collected from Maine to western Ontario, Iowa, and Louisiana, was impressed with the intergradations between *angustifolia* and *latifolia*.

The writers have found *angustifolia* a definite entity, and puzzling intermediates very few. Its American synonymy is as follows: *Typha angustifolia*, Linnaeus, 1753; *T. angustifolia* var. *calumetensis*, Peattie,[24] 1926.

---

19 Edward Lee Greene. Studies in the botany of California and parts adjacent. VI. 1. Notes on the botany of Santa Cruz Island. Bul. Calif. Acad. Sci. 2: 413-414. 1887.

20 M. L. Fernald. Midsummer vascular plants of southeastern Virginia. Rhodora 37: 385-387. 1935.

21 Walter Conrad Muenscher. Aquatic plants of the United States. Pages 17-18. 1944.

22 Muriel V. Roscoe. Cytological studies in the genus Typha. Bot. Gaz. 84: 403. 1927.

23 Barbara May Calhoun. Intergradation between *Typha latifolia* and *Typha angustifolia*. Univ. of Wisconsin thesis. 9 pages, mimeo. 1947.

TYPHA LATIFOLIA

The identity of *T. latifolia* has been relatively free from confusion. Its American synonymy is as follows:

Typha latifolia, Linnaeus, 1753.

HABITAT AND RANGE

The four species grow in similar situations. In one Delaware marsh all four can be reached without shifting one's feet, while in two Potomac River marshes they grow within a few rods of each other. Mr. John Thomas Howell has found all of them on the shore of a small artificial lake in Marin County, California. *Typha latifolia, angustifolia,* and *glauca* frequently grow together from central Maryland northward, and *T. latifolia, angustifolia,* and *domingensis* from southern Maryland southward. Each species tolerates some salinity. The apparent order of tolerance, in decreasing degree, is *domingensis, angustifolia, latifolia,* and *glauca*. *T. domingensis* appears to grow only in soils with appreciable salt content, whether coastal or inland. *T. angustifolia* grows mostly in basic waters. *T. latifolia* is the only species that tolerates acidity. *T. glauca* grows best in alluvial soil in basic waters. Luxuriant growths of *glauca, latifolia,* and *angustifolia* have been found in water containing some sewage.

Cat-tail seeds germinate well on wet mud. Once established the plants spread vegetatively under water of varying depth. *Typha latifolia* frequently occurs in small seepage areas, even on slopes and at high altitudes. The other species grow mostly in large lowland marshes.

The information on the range maps (Figs. 11-14) is based on specimens in the herbaria listed earlier and on many published records and personal observations. It is new in restricting the range of *T. angustifolia* from that given in most manuals (which have included *T. domingensis* with it); extending the range of *T. domingensis* northward from that given by Graebner[11] and Fernald;[20] adding many localities for *T. glauca* (formerly known as *T. angustifolia* variety *elongata*); and extending the range of *T. latifolia* to central Alaska (Hugh T. O'Neill, 1947). The same four species grow in Europe, where they have similar distribution.

The morphological data on the charts summarize the writers' observations. In the case of *T. domingensis* these agree with those published by Morong,[17] Graebner,[11] and, especially, Gèze[18] on floral morphology and by Fernald[20] on gross characters. Most of the characters described for *T. glauca* were recognized by Godron,[7] Figert,[9] and Ascherson and Graebner.[10] No author has been found who distinguished all four species.

---

24 Donald C. Peattie. Indiana dune plant notes. Amer. Midl. Nat. 10(6): 129-130. 1926.

FIELD CHARACTERS

1. Full grown pistillate spikes (persisting for several months)

1. Color

latifolia—very dark greenish brown to reddish brown; becoming whitish as stigmas wear off.

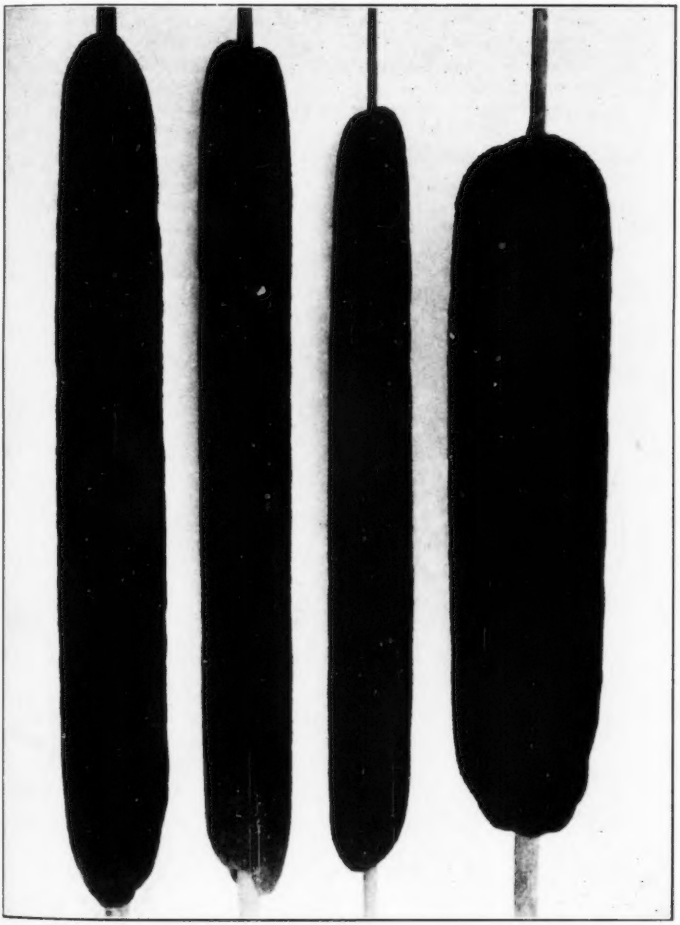


Fig. 2.—Pistillate spikes, left to right, of *Typha glauca, domingensis, angustifolia* and *latifolia;* reduced one-third.

angustifolia—dark brown or sometimes reddish brown; becoming greenish brown as stigmas wear off; finally mottled dark brown and buff.

glauca—reddish brown (chestnut) or sometimes dark brown; becoming mottled reddish brown and buff as stigmas wear off.

domingensis—light cinnamon brown; becoming buffy or grayish.

2. Length of space between pistillate and staminate spikes

latifolia—usually none; rarely as much as 8 cm.

angustifolia—usually about twice the diameter of the pistillate spike; varies from 0.5 to 12 cm.

glauca—usually less than the diameter of the pistillate spike; varies from none to 4 cm.

domingensis—usually about the diameter of the pistillate spike; varies from 0.7 to 4.5 cm.

3. Size and proportion

latifolia—usually about 6 times as long as thick; varies from 10 to 18 cm. in length and 1.8 to 3 cm. in thickness, frequently a little thicker at the top.

angustifolia—usually 6 to 10 times as long as thick; varies from 8 to 20 cm. in length and 1.3 to 2 cm. in thickness, thickness uniform.

glauca—usually 6 to 10 times as long as thick; varies from 10 to 25 cm. in length and 1.8 to 2.5 cm. in thickness, thickness uniform.

domingensis—usually about 10 times as long as thick; varies from 15 to 25 cm. in length and 1.5 to 2.2 cm. in thickness, thickness uniform.

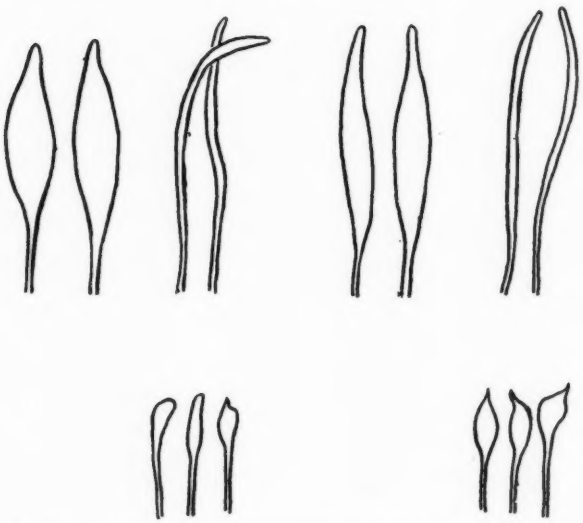


Fig. 3.—Stigmas, above, left to right, of *Typha latifolia, angustifolia, glauca* and *domingensis*; enlarged 25 times. Bracts, below, left to right, of *Typha angustifolia* and *domingensis;* enlarged 25 times.

4. Height of spikes in relation to leaves

latifolia—spikes moderately overtopped by leaves.

angustifolia—spikes much overtopped by leaves, sometimes by half their length.

glauca—spikes moderately to much overtopped by leaves.

domingensis—spikes as tall as, or moderately overtopped by, leaves.

5. Details observable with a hand lens

A. Stigmas

latifolia—medium brown to very dark brown, lance-ovate, conspicuously fleshy, usually long persistent.

angustifolia—dark brown, linear, not fleshy, persistent to deciduous.

glauca—reddish brown (chestnut), lance-linear, slightly fleshy, usually persistent.

domingensis—light cinnamon brown, linear, not fleshy, soon deciduous.

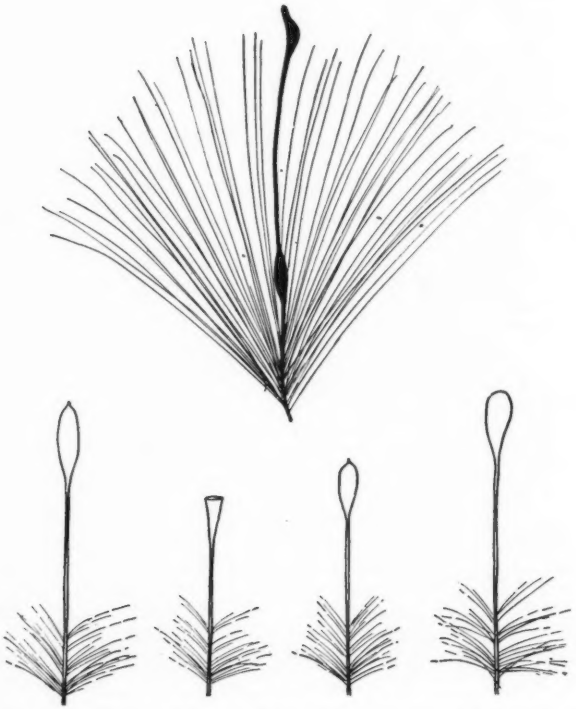


Fig. 4.—Fertile flower, above, of *Typha latifolia;* enlarged five times. Abortive flowers, below, left to right, of *Typha latifolia, angustifolia, glauca* and *domingensis* (hairs as long as stipe and ovary); enlarged five times.

B. Bracts

latifolia—none.

angustifolia—blades very dark brown, opaque and firm, usually spatulate and blunt (on long slim stalks, apparently from the axis).

glauca—usually none, rarely a few with medium brown, spatulate, blunt blades.

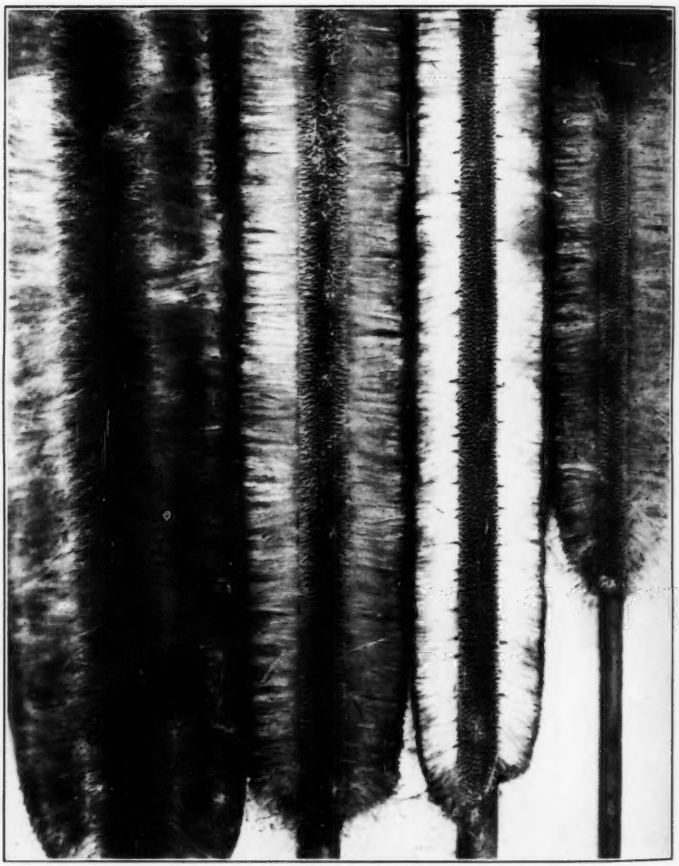


Fig. 5.—Pistillate spikes, left to right, of *Typha latifolia, glauca, domingensis* and *angustifolia* (fluff partly removed to show pedicel-covered axes); enlarged approximately one-fifth.

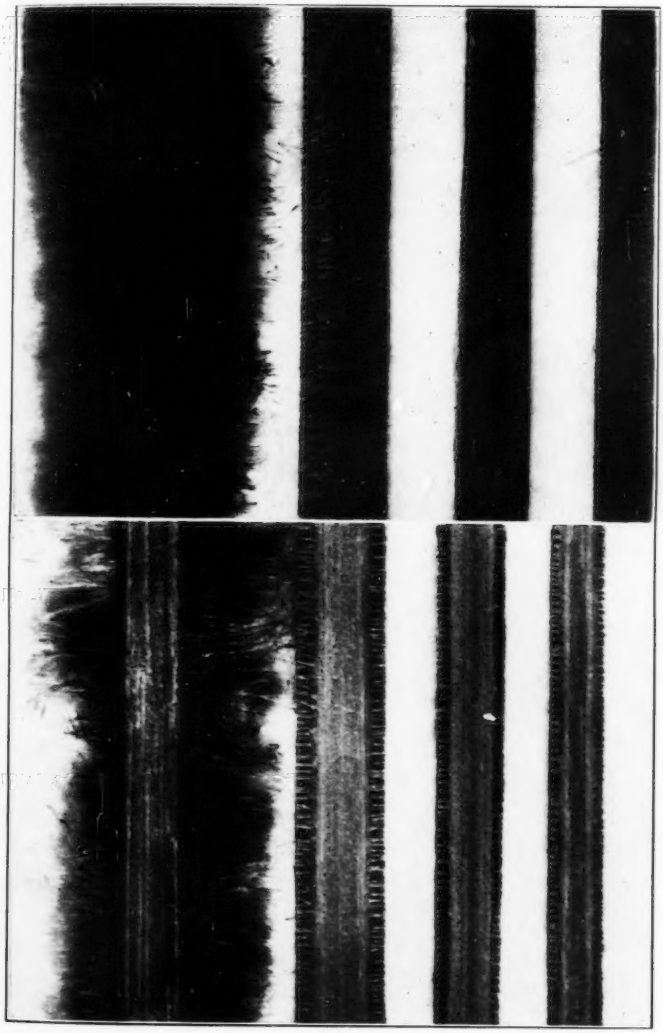


Fig. 6.—Pedicel-covered axes of pistillate spikes, left to right, of *Typha latifolia*, *glauca*, *domingensis* and *angustifolia*; enlarged two times.

domingensis—blades light brown, translucent and spongy, usually ovate and apiculate (on long slim stalks, apparently from the axis).

C. Fertile flowers—similar in each of the four species, each flower composed of a stipe, ovary, style, and stigma; the stipe bearing 40-60 hairs of about even height with the style. Many of the fertile flowers are borne directly on the axis of the inflorescence, packed between the bases of the compound pedicels; others are borne on the lower nodes of these pedicels (Graebner11 described the relation of the fertile and abortive flowers).

D. Abortive flowers—in each of the four species composed of a stipe with a club-shaped body at its end (Calhoun23 called attention to the different shapes in *T. latifolia* and *T. angustifolia*); the stipe bearing 25-40 hairs of about even height with the body. Usually three or four abortive flowers are borne on the upper nodes of each compound pedicel. In at least *T. latifolia* and *T. glauca* the base of

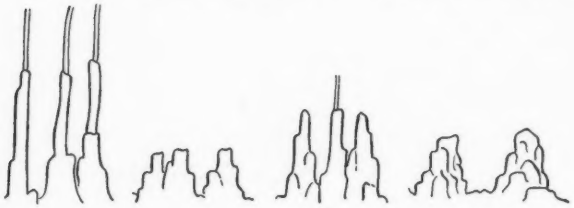


Fig. 7.—Compound pedicels, left to right, of *Typha latifolia, angustifolia, glauca* and *domingensis;* enlarged ten times.

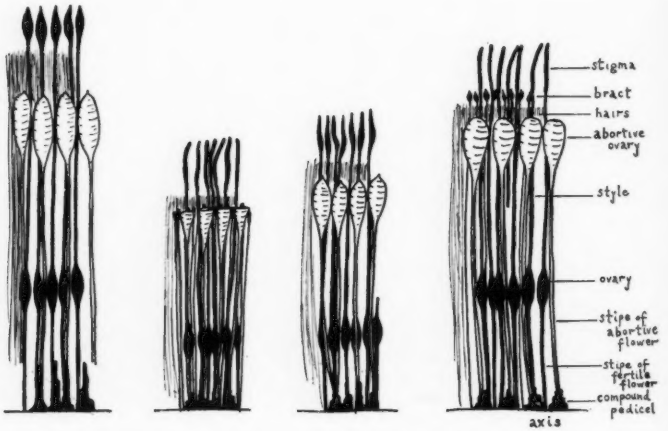


Fig. 8.—Sections from axis to exterior of spikes, left to right, of *Typha latifolia, angustifolia, glauca* and *domingensis* (shading diagrammatic); enlarged five times.

the uppermost flower is hollow and covers the prolonged tip of the pedicel.

E. Compound pedicels (described, in part, by Morong,[17] Graebner,[11] Wilson,[25] and Gèze[18])—thickly distributed over the axis of the inflorescence, and differing in shape and spacing in each species.

25 Percy Wilson. Typhaceae. N. A. Flora 17: 3-4. 1909.

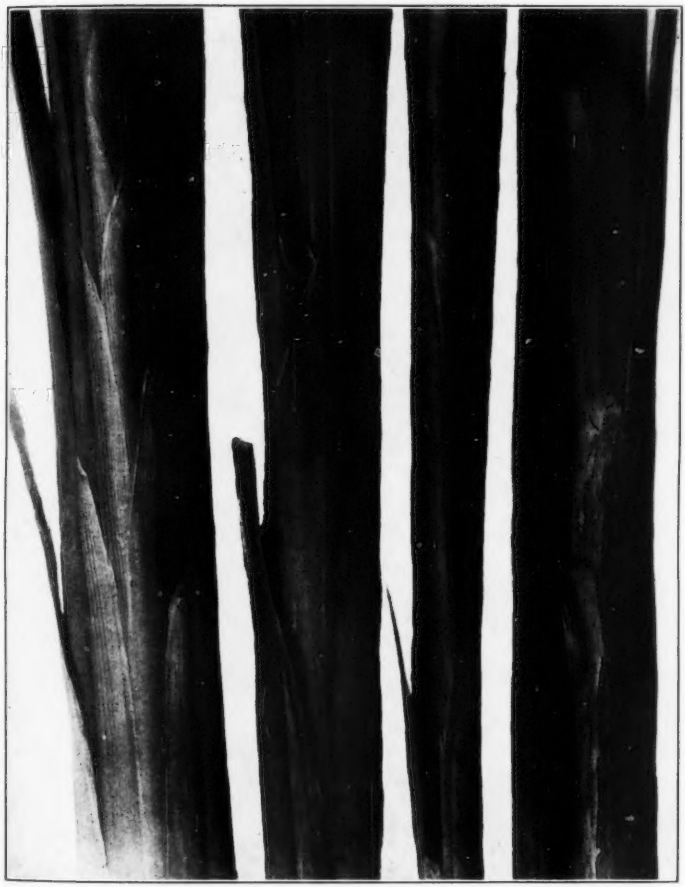


Fig. 9.—Non-flowering shoots showing, left to right, tapered leaf sheaths of *Typha latifolia* and *domingensis* and auriculate sheaths of *Typha angustifolia* and *glauca*. Reduced approximately one-third.

latifolia—hair-like, 1.5 to 3.5 mm. long. closely spaced.

angustifolia—papillate, 0.5 to 0.7 mm. long, closely spaced (about 20 to the square millimeter).

glauca—between papillate and hair-like, 0.6 to 1.2 mm. long, closely spaced (15 to 20 to the square millimeter).

domingensis—papillate, 0.5 to 0.8 mm. long, more openly spaced (5 to 10 to the square millimeter).

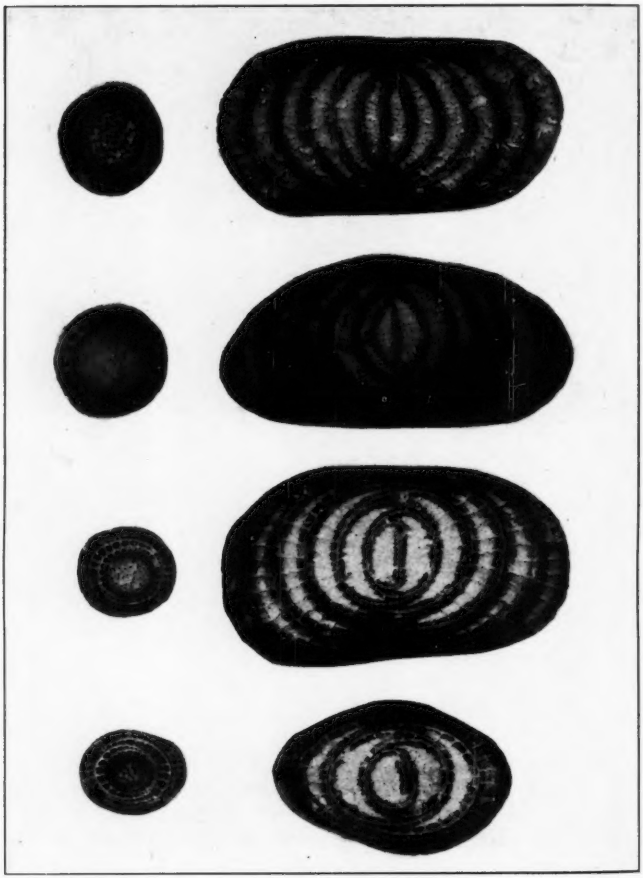


Fig. 10.—Cross sections of flowering stems and butts, top to bottom, of *Typha latifolia, domingensis, glauca* and *angustifolia*. Actual size.

F. Arrangement of floral structures on the surface of the spike

latifolia—surface a densely matted mass of lance-ovate, fleshy stigmas; finally, when the stigmas have fallen, with many rounded abortive flowers inconspicuously imbedded among the tips of innumerable hairs.

angustifolia—surface a densely shaggy or curly mass of linear stigmas; or, when the stigmas have fallen, with many rounded abortive flowers conspicuously imbedded among the tips of innumerable hairs and occasionally the tiny spatulate, blunt blades of bracts (bracts usually show above hairs near base of spike.)

glauca—surface a densely curly mass of lance-linear stigmas; finally, when the stigmas have fallen, with many rounded abortive flowers rather conspicuously imbedded among the tips of innumerable hairs.

domingensis—surface a loosely curly mass of linear stigmas interspersed with the tiny ovate, apiculate blades of many bracts; or,

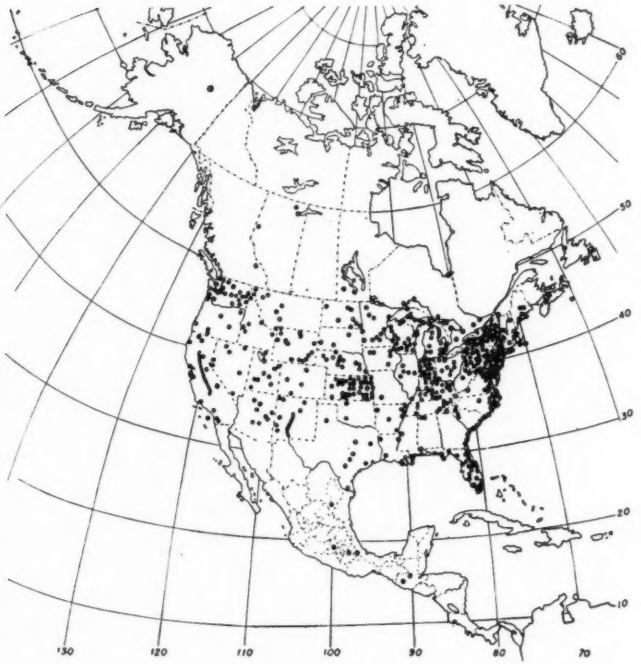


Fig. 11.—*Typha latifolia* in North America. Floras report it as widespread in Wyoming, Saskatchewan, Manitoba, North and South Dakota, Minnesota, Wisconsin, Iowa, Missouri, Illinois, Oklahoma, Tennessee, Alabama, Nova Scotia, Vermont, Massachusetts, Connecticut, Delaware and Maryland.

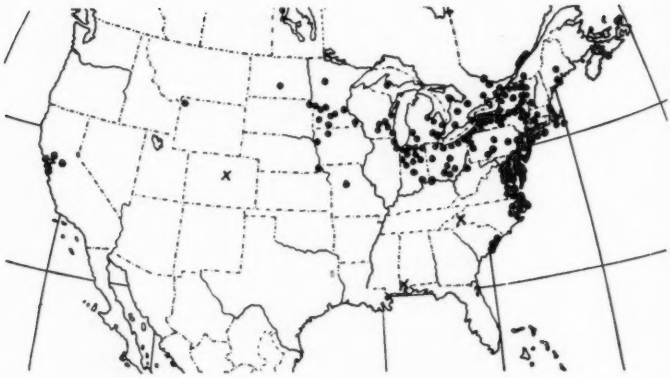


Fig. 12.—*Typha angustifolia* in North America. X's indicate introductions.

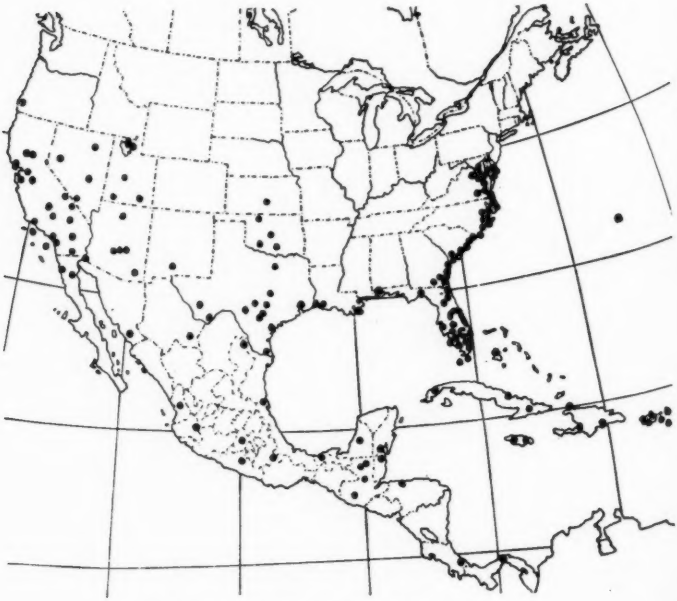


Fig. 13.—*Typha domingensis* in North America.

when the stigmas have fallen, with the blades of many bracts loosely overtopping many rounded abortive flowers conspicuously imbedded among the tips of innumerable hairs.

II. Leaves (similar on flowering stems and non-flowering shoots)

1. Width, cross-section shape, and color of blades

latifolia—usually 8 to 15 mm. wide, nearly flat, light green.

angustifolia—usually about 5 mm. wide, occasionally wider, strongly convex on the back, dark green.

glauca—usually 6 to 12 mm. wide, moderately convex on the back, medium to dark bluish green.

domingensis—usually 6 to 12 mm. wide, moderately convex on the back, light yellowish green.

2. Sheaths

latifolia—usually tapering into the blade, sometimes truncate.

angustifolia—usually auriculate.

glauca—usually auriculate as in *T. angustifolia*, sometimes tapering and resembling broad-sheathed *T. latifolia*.

domingensis—tapering into the blade.

Fig. 14.—*Typha glauca* in North America.

3. Cross sections of non-flowering shoots (butts)

A. Shape of butts (see Fig. 10), number and cross-section shape of leaves

latifolia—12 to 16 leaves, central ones flat and thin, outer thin concave-convex.

angustifolia—7 to 13 leaves, central ones thick plano-convex, outer thick concave-convex.

glauca—8 to 12 leaves, central ones moderately plano-convex, outer thick concave-convex.

domingensis—6 to 9 leaves, central ones moderately plano-convex, outer thick concave-convex.

B. Color of pith

latifolia—white.
angustifolia—white.
glauca—yellowish buff.
domingensis—white.

III. Staminate spikes (ephemeral)

1. Pollen color and pollen grain structure (latter observable with a microscope)

latifolia—deep orange yellow, 4-celled.
angustifolia—light lemon yellow, 1-celled.
glauca—golden yellow, 1-celled.
domingensis—golden yellow, 1-celled.

2. Bracts (observable with a hand lens)

latifolia—simple, hairlike, white.
angustifolia—simple or forked, hairlike to linear, brown.
glauca—simple or forked, hairlike, whitish to light brown.
domingensis—cuneate, laciniate, brown.

Book Reviews

THE BRAIN OF THE TIGER SALAMANDER. By C. Judson Herrick. The University of Chicago Press, Chicago, Illinois. 1948. 409 pages, 113 figures. $5.00.

Among comparative neurologists Professor C. Judson Herrick is conceded to be the foremost authority on the anatomy of the central nervous system of tailed amphibians. In this book he has presented and discussed material collected during 50 years of intensive study of the vertebrate nervous system with emphasis on the amphibian brain.

The book is divided into two portions, different in manner of presentation and in aim. In the early chapters of Part I, after a brief introduction, the gross form and subdivisions and the histologic structure of the salamander nervous system are discussed. The nervous system is divided into its major regions (such as the spinal cord, the medulla oblongata and the pallium) with a brief discussion of the significance of each region. This relatively conventional subdivision of the nervous system is followed, in Chapter V, by a thought-provoking functional analysis of the salamander brain into three longitudinal zones—a dorsal receptor, a ventral motor and, between and overlapping them, an intermediate zone of correlative or integrative significance.

The succeeding chapters of Part I are, in the reviewer's opinion, the most important in the whole book. Chapter VI entitled "Physiological Interpretations" begins with the premise that a primitive brain like that of the tiger salamander performs functions which are primarily analytic. The environment is analyzed by the sensory side of the arc, the motor response is an adjustment to changing external conditions. However, before functioning neuron arcs, as indicated by an orderly response to stimulation, can be demonstrated, differentiation must occur within the integrative mechanism of the central nervous system. Such differentiation will follow a predetermined inherited pattern, although this early pattern may be modified during subsequent development. In this connection Dr. Herrick discusses the important contributions of Coghill on the correlation between growth and behavior in the developing amphibian tadpoles. He stresses particularly Coghill's principles that the total responses of the body musculature to a given stimulation—or the "total patterns" of activity—precede in development the local reflex responses or "partial patterns".

Chapter VII deals with the phylogenetic development of the vertebrate cerebral hemispheres and, most particularly, with the evolution of the cerebral cortex. Although based on the detailed information available in the highly technical publications of the author and other research workers, this account is presented in the clear-cut, simple and readable form characteristic of the Herrick style at its best.

Part I closes with a discussion of morphogenesis. Dr. Herrick emphasizes the gradual development of the conception of morphogenesis as "the visible record of phylogenetic history". He points out the danger of over-simplification in attempts to explain morphological problems, deplores the failure to recognize the correlated development of form and function, and emphasizes that experimental and anatomical studies must supplement each other in any attempt to solve morphological problems. He believes that, as in other fields of human activity, the motivating force directing research along the lines of comparative neurology should be a better understanding of human life and of the conditions which influence it.

The second part of the book is devoted to an account of the morphological pattern —the nuclear groups and the fiber connections—of the brain of the tiger salamander. It is intended as a supplement to Part I, documenting the statements made in the early part of the book, and will be of especial interest to comparative neurologists.—ELIZABETH C. CROSLY, University of Michigan Medical School, Ann Arbor.

HENRY A. WARD. By Roswell Ward. The Rochester Historical Society Publications. Vol. XXIV. Rochester, New York. 1948. 1st Ed., xiv + 287 pp., 15 pls. $4.00.

Another much traveled figure in the nineteenth century, Henry Adams, reflected that the era provided no transition between the eighteenth and twentieth centuries except in terms of physical and temporal growth. The life of Henry A. Ward, here presented by his grandson as the "museum builder to America," seems to epitomize that analysis. It was an age that moved in restless dynamism to build and to expand in all directions with little pause for assimilation and weighing of values.

The early evidenced bent toward geology and natural history generally drove Henry Ward with ever increasing force. Working through a maze of difficulties he finally managed to attend college only to find the horizons there too narrow and too circumscribed. But he had come under the influence of Louis Agassiz who insisted that his students study nature rather than books. So Ward moved on under this impetus to provide the schools of America with representative collections of objects of natural history which he saw as vitally necessary for the proper teaching and understanding of the natural sciences. This idea finally grew to the founding of the now famous "Ward's Natural Science Establishment" at Rochester. The publications of Darwin about the middle of the nineteenth century made evolution a point about which thoughts and emotions swirled and eddied and made the collection of fossil and contemporary forms particularly important to the natural scientists of the period. "Ward's" fast became a clearing house for information and an important source of specimens for American institutions and research men.

But the story of the man behind these undertakings and the collecting trips that zigzagged across oceans and continents make absorbing reading. (But this reviewer cannot help wish that the body of the book had been written with the verve and insight which the author displayed in his dedication of the work.) Collecting endeavors ranging from the cloistered court of the Shah in Teheran to the weird crocodile pits in the upper valley of the Nile, share interest with the array of personalities encountered by Ward; not the least among whom were Louis Agassiz, Buffalo Bill, P. T. Barnum, the Widow Clicquot and the washerwoman of Fernando Po.

Ward's life during the eighties as described by the author summarizes quite well the entire life of the man. "Ward was engaged in more and more extensive collecting campaigns, while no important exposition was permitted to go without an exhibit. These were days of tremendous work, of far-flung enterprise and hit-or-miss financial policy that would horrify Ward's cousins when they finally tried to untangle the accounts. . . . Ward was never hampered by bookkeeping."

Although one follows the day-by-day activities of Henry Ward, and they are given with a fair amount of color and convey something of the quenchless ambition of the man, the reader is left to wonder what went on inside the man. What sort of bond and understanding actually existed between him and his wife, Phoebe Howell, and their family with whom he apparently spent so little time. No one can guess how important Amelia Martin was in his life any more readily than one can understand what kind of emotions prompted his second marriage when the wealthy Mrs. Coonley became Mrs. Coonley-Ward. But perhaps such considerations are hard to catch in reviewing the rapid rush of movement that was Henry A. Ward's life; terminated ironically enough when he was run down by an automobile 80 miles from his birthplace. The book provides a worthwhile addition to Americana.—PAUL S. STOKELY, University of Notre Dame, Notre Dame, Indiana.

41 (1)

cations.
$4.00.

ted that
cept in
nted by
lysis. It
rections

Henry
finally
circum-
that his
petus to
ral his-
of the
Ward's
out the
d emo-
forms
came a
merican

ips that
eviewer
insight
s rang-
s in the
ered by
Barnum,

te well
llecting
. These
policy
nts. . . .

e given
of the
nd and
d their
portant
kind of
he Mrs.
ing the
enough
ok pro-
f Notre